THE BREWER.

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THE BREWER

A Familiar Treatise

ON THE

ART OF BREWING,

WITH SPECIAL DIRECTIONS FOR THE MANUFACTURE OF

PALE ALE & BITTER BEER,

AND THE USE OF

SUGAR BY BREWERS.

NEW EDITION.

LONDON:
W. R. LOFTUS, 321, OXFORD STREET.
SIMPKIN, MARSHALL, & CO., STATIONERS' HALL COURT.

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ADVERTISEMENT.

In the present revised issue of this work, which has passed through several editions with a large amount of popular favour, special chapters are given on the manufacture of Pale Ale and Bitter Beer, and upon the use of Sugar in brewing. The mode of determining the *specific gravity* of worts as practised by the revenue officers in assessing the Beer duty at breweries is fully described, and illustrated by examples.

An inspection of the contents of this small volume will show that there is hardly a question or a difficulty that can arise, either as respects the principles or the practice of brewing in general, that is not met and answered in a plain and satisfactory manner.

Contrary, however, to the usage of most writers on brewing, no remarks are offered on Adulteration, nor are any hints thrown out as to the means by which brewers may *fraudulently*, yet safely, enrich themselves, at the expense of the public health and pocket. It has been found, nevertheless, that the sale of the work has not been in the least degree injured by this omission.

N.B.—The present edition has been carefully adapted throughout to the new Excise law affecting Brewers for sale.

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THE BREWER.

CHAPTER I.

General Principles of the Art of Brewing.

Definition of a Malt Liquor.—Every malt liquor, properly so called, consists of extract of malt and hops, fermented by means of yeast; the malt, as being the principal or characteristic ingredient, confers its name upon the compound. No materials besides these can be said to furnish a beverage entitled, in strictness, to the designation of a genuine malt liquor. In modern times, however, certain partial substitutes for malt, and occasionally also for hops, have been employed on an extensive scale, without exposing the brewer to the charge of positive or intentional adulteration, and without altering the quality of the product so far as to forbid its being classed under the head of malt liquors.

Varieties of Malt Liquors.—*Beer and Ale.*—The word "Beer" is now-a-days most frequently used to indicate malt liquors in general, instead of being applied, as seems formerly to have been the case, to one particular kind only. Thus, in a similar way, "Wine" stands as a comprehensive term for Port, Claret, Madeira, and all other descriptions of fermented grape juice: "Spirits" again, represents collectively Rum, Brandy, Whiskey, and the like.

In and around London, that which is elsewhere styled "Porter" is commonly spoken of as "Beer," and in some of the rural districts it is or was customary to distinguish the stronger or better classes of malt liquor by the title of "Beer." But, with these slight exceptions, the practice,

in the present day, is, as above stated, to regard "Beer" as the type of malt liquors in general, and, indeed, of all other beverages prepared by a process of *brewing*, the several well-known varieties of ale, porter, and stout composing the principal members of the group. Whenever the term is used in a special or more restricted sense, it is with a descriptive prefix, as, for example, *bitter* beer, *spruce* beer, &c.*

Ale of all kinds is brewed chiefly from pale malt, and is in most places of a light amber colour, although, occasionally, a deeper tint is given either by the use of a portion of high dried malt, by protracted boiling, or, in some instances, by the addition of a little roasted or black malt or sugar-coloring to suit the taste of the locality; for in this, as in the case of many other beverages, such as coffee, tea, &c., depth of color is with the great bulk of consumers regarded as an indication of strength or goodness. In the manufacture of what is called "Pale Ale" only the finest and lightest dried malt is used: the flavor and odour of choice hops are caused to predominate slightly, and the whole when skilfully prepared is beyond doubt the most elegant, wholesome, and agreeable form of malt liquor that has ever been produced. It is in large request at the present day. *Bitter beer* has, as a rule, less body than pale ale, and is more highly hopped. It resembles, in fact, a medicinal tonic rather than a popular beverage; but it has many admirers. *Mild ale* differs from pale ale in being sweeter, somewhat stronger, and in having no marked predominance of the flavor or smell of hops. This is of the kind usually termed

* Before the introduction of Hops into England, which is reputed to have taken place about the year 1524, during the reign of Henry VIII, "Ale" seems to have been the popular name in this country for malt liquor. As the use of hops was derived from Germany, the German word *bier* (Saxon, *bere*, barley) was probably first adopted under the equivalent English form, *beer*, to distinguish the hopped liquor from *ale*, the unhopped.

There is strong reason for believing that the term "Ale" is of Danish or Scandinavian extraction, since *ol* is still the designation of malt liquor in the Scandinavian tongues. On the invasion of Britain by the people of this race it is not unlikely that *ol* or *ale* may have displaced the *beor* of the Anglo-Saxons which that nation had in common with other Teutonic communities.

Porter and stout are beverages of comparatively recent introduction; the supposed origin of the former term is noticed in the text above.

home-brewed ale. Old ale has considerable strength, since a weak ale will not keep so as to remain sound and potable when it has attained to any age. In ordinary old ale there is a considerable development of acid, which leads to such ales being called also *hard ales. Table beer*, or *small beer*, has little body or spirituousness. It is, as the name imports, suitable chiefly for consumption at meals. *Spruce beer* (brown and white) is made from treacle or refined sugar fermented with essence of spruce—an exudation from the Norway spruce tree—instead of hops. This, however, should be classed rather as a wine than a beer. Of *ginger beer*, and the various *herb beers*, it is unnecessary to treat in the present work, as none of these, notwithstanding the names given to them, have any real similarity to a malt liquor.

Porter and Stout.—The beverage known as "Porter" differs from ale chiefly in respect of its being artificially coloured by the use of black or roasted malt, which also imparts a bitter flavor; in its superior briskness, and in being more highly hopped than common ale. In point of strength, porter ordinarily stands about mid-way between light and strong ales, although it is often brewed of a strength very slightly above that of table beer. Stout is simply a richer or stronger description of porter, and may be said to have nearly the same relation to the higher qualities of mild ale that porter holds with regard to pale ale or bitter beer. The origin of the term "Porter" has been ascribed by most writers on brewing to the fact of the beverage having, from its cheapness and refreshing properties, been at first consumed principally by *porters* or other working-men of that class: but the true explanation seems to be that the liquor was first manufactured by a brewer of the name of Porter, and that the invention came, as is often the case, to be called after the inventor.

Until within the last twenty or thirty years, porter was always brewed from a mixture of highly dried malts, the varieties consisting—1st, of brown or amber malts, such as are prepared by raising the heat of the kiln to about 160° F., for a short time before the malt would, on ordinary occasions, be removed from it as finished, and thus slightly scorching the kernel of the grain; and, 2nd, of *blown* or

snap malt, specially made for porter brewing, by applying a very strong heat to the green malt as soon as it is placed upon the kiln, by means of faggots of wood, as will be more particularly described in the next chapter, under the head of MALTING. The sudden, fierce heat has the effect of *blowing* out the husk from the kernel, and thus giving an appearance of great bulk to the grain: hence the name *blown malt.*

At present, however, blown malt is but little used, it having been found that a large portion of the saccharine matter is charred or destroyed by the strong heat, thereby producing much unnecessary waste, and that a small quantity of *roasted* malt gives all the color and flavor that the porter brewer can desire, while it enables him to prepare the body of the liquors in the best and most economical manner from pale malt only.*

At some breweries it is still the practice to use a portion of brown or amber malt, as well as pale and roasted malt, in the manufacture of porter, it being considered that a coarse, empyreumatic taste is given to the liquor when the requisite color is derived from no other material than roasted malt.

Beer, Wine, and Cider Compared.—Wine and Cider consist of the naturally fermented juices of certain *fruits.* Beer, on the other hand, is essentially an extract of malted grain or a solution of ordinary or patent sugar, fermented with yeast and flavoured and preserved with hops or bitter substance sometimes used in place of or in addition to hops. The quality of the product obtained from malt and hops only is esteemed much finer than that of beer manufactured to any extent from the other materials above-mentioned, however skilfully the genuine liquor may be imitated; and

* When malt became dearer in consequence of the heavy tax laid upon it, and the great increase which took place in the price of barley during the wars of the French Revolution, the brewers discovered that a greater quantity of wort of a given strength could be obtained from pale malt than from brown. The result was that pale malt came to be generally substituted for the larger portion of the brown malt used in the brewing of beer, while the addition of a little roasted or partly carbonized malt was found to communicate any shade of color or degree of flavor that could be desired, and thus at once improved and cheapened the production of porter and stout.

there is no doubt that the popular preference in this respect is well grounded. But in seasons when there is a scarcity of malt or hops, brewers, in order to meet the increasing and rapidly-growing demand for beer, are obliged to have recourse to the best substitutes at their command, and these are found, as has just been stated, in the use of some species of ready-made sugar and of bitters most nearly allied in flavor and properties to the hop. The practice of adulteration of a pernicious or directly fraudulent character is not of course here taken into account.

Sugar.—All fermented liquors must have had *sugar* as their basis or principal element. It should be clearly understood that nothing but sugar will ferment, that is, undergo the change which results in the production of spirit or alcohol. Other substances, such as starch or gum, occurring in plants, may appear to ferment and yield a portion of spirit without previously experiencing any transformation; but in reality it is indispensable that these bodies should first be converted by some agency into an equivalent quantity of sugar having the same composition as that which exists in honey or the juices of matured fruits. The agencies capable of effecting this change will be explained a little further on.

Nature provides in the juice of ripe grapes or apples a stock of ready-formed sugar from which wine or cider may be prepared, simply by allowing the expressed liquid to stand in vessels at a certain temperature until fermentation begins and proceeds to the desired extent, when it is checked by suitable means, the addition of yeast being in either of these cases unnecessary, as the juice contains its own peculiar ferment associated with its sugar and other constituents. But in the making of a fermented beverage from grain, the production of sugar within the body of the seed, by causing germination to take place under circumstances which admit of the natural process being controlled and brought to a close at pleasure, must be accomplished before a liquid capable of fermenting can be obtained. In other words, the grain must first be *malted*, as until then no saccharine liquid of any value or richness can be produced from it by infusion in water. In this respect, therefore,

there is an important difference between the operations conducted by the wine or cider maker and the beer brewer respectively. The one has a sweet liquid, as it were, ready to his hand on merely subjecting the gathered fruit to pressure; while the latter is compelled to go through the expensive process of "saccharifying" his raw material before he can command a supply of soluble sweet matter which, on being heated with water, will yield an infusion fit for fermentation. In the first case, also, as the juice of the fruit contains its own natural ferment, which acts spontaneously under certain conditions of temperature, the wine or cider maker is saved the necessity of having to provide and use an independent or artificial ferment—such as yeast—and this with the beer brewer is one of the most troublesome and delicate parts of his entire process.

The disadvantage—if it may be so called—which the brewer is at as regards the malting of grain before a sweet infusion can be obtained from it, does not, of course, exist when he prepares beer from any of the varieties of common sugar, or from the soluble saccharine lately introduced, the only thing then requisite being to dissolve the material in water; but the solution thus produced refuses like extract of malt to ferment properly without the addition of yeast, and that, moreover, in a greater quantity than malt liquor demands. But as the use of much yeast is apt to impart a disagreeable flavor to the beer, and as sugar, except in times of scarcity of good barley, is seldom employed beyond a very limited extent by brewers, it is still the fact that in the making of beer the several operations to be gone through are more tedious, costly, and difficult than those necessary in the production of wine or cider.

Outline of the Process of Brewing in General.—Having then in malted grain or sugar the principal ingredient of the product which he wishes to manufacture, the brewer proceeds as follows*—

Grinding or Crushing.—As the grains of malt in their whole state would not yield their soluble contents to water until after a long period of infusion, and then only in a very

* The operation of malting will be fully described in the next chapter.

imperfect and unsatisfactory manner, it is necessary, as a first step, that the malt should be effectually broken up or powdered so as to allow of the water coming into immediate contact with every particle of the interior of each grain, and thus exerting its full solvent power in the most advantageous way upon the mass submitted to its action. To this end, the malt may be ground, cut into small pieces, bruised, or crushed. Grinding may be effected by placing the malt between two revolving circular stones, as in the process of ordinary flour or linseed meal grinding. Cutting and grinding together are best accomplished by means of a large steel mill acting on the principle of a coffee mill. Crushing or bruising is performed by passing the whole malt between two cylindrical steel rollers, arranged horizontally at a certain distance apart, with adjusting screws for altering the relative position according to the fineness of the meal required.

It may be remarked on this subject, that malt, if ground between stones or in a steel mill, and thus reduced to a fine powder, is apt to "set," that is, form an impenetrable paste with the hot water in the mash tun. It is considered, therefore, as a well-established axiom in brewing, that bruising or crushing into a coarse meal is the best method of preparing *malt* for the mash tun that can be adopted by public or private brewers. The case of raw grain, when used as a partial ingredient of the brewer's grist, is, however, very different from that of malt. The action of stones, or of a mill, is requisite to break up the firm structure of the unmalted corns in a degree sufficient to prevent loss by imperfect saturation with the mashing liquor.

The malt when ready for mashing is technically called "grist," that is, ground materials. It is usual to expose the grist for a *short time* to the air before using it, so that it may become mellow by the absorption of a little humidity, and thus incur less risk of "setting" when mixed with the hot mash liquor.

Mashing or Infusing.—The bruised and mellowed malt is now put into a wooden or iron vessel of circular shape called the mash tun, and mixed with hot water. At a height of an inch or two above the proper bottom of this vessel is placed a moveable "false bottom," consisting of a

frame of closely-fitting boards or thin iron plates pierced with numerous small, funnel-shaped, holes which permit a liquid to flow through easily, but prevent the passage of any undissolved solid matter, such as particles of the moistened grist. It is evident that the object of the false bottom is to facilitate the drawing off of a clear solution from the malt when it has been sufficiently infused. Taps or cocks of ordinary construction, or in some cases simple plug holes, are inserted in the space between the two bottoms of the tun; from these when opened, the water, after it has become impregnated with the soluble parts of the malt, and now termed in the language of brewers, "wort," or "worts," issues as a bright, transparent, liquor, and is received into a vessel called the "underback," placed immediately beneath. Water for mashing is also frequently introduced into the tun through the pipes that serve for drawing off the malt. The dry grist is either introduced through a "hopper" erected over the mash-tun, or is emptied from sacks over the edge of the vessel on to the false bottom just described. Water,* heated in a copper and brought to a certain regulated temperature, is then admitted, and the operation of blending it with the grist at once commenced. In small breweries the stirring of the materials together is often effected by no other means than the motion of long poles called "mashing oars," supported on the edge of the tun and worked backwards and forwards by hand; a thorough admixture of the malt and water can hardly be accomplished in this rude and laborious way, unless the brewing is of very limited extent; on the large scale, revolving machinery driven by steam is almost always employed, a more satisfactory result being thus attained in a much shorter time.

It will be readily understood to be of the highest importance that a complete and intimate blending of the grist and mash liquor should take place. Any imperfectly moistened lumps or clots that may form in the contents of the tun, and escape being broken up by the machinery, produce not only a direct loss of material, as the water is unable to penetrate to the interior of the mass and dissolve

* Some remarks on the kind of water most suitable for brewing will be given in Chapter II.

out what is soluble in it, but also lead to serious ill effects by generating acid which may infect the entire mash. This point will be more particularly adverted to in the chapter on mashing.

By many brewers the heated water is first introduced into the mash-tun either at the top or through the pipes inserted in the space between the real and false bottom of the vessel, and the malt then gradually added, with constant stirring. A further improvement—not so extensively adopted as it should be—consists in the use of a small mashing cylinder placed horizontally over the tun. All the grist is caused first to pass slowly though this apparatus. At the time it enters, heated water is also admitted, and, as the cylinder is kept constantly revolving in the same manner as a barrel churn, a close amalgamation of the materials is effected before the onward-moving mass has reached the open mouth of the cylinder and discharged itself into the mash tun below. The larger machinery in the tun is kept in movement all the while, so that it is almost impossible any "balling" should take place, as the arrangement ensures that every portion of the meal shall be thoroughly mixed up with a right quantity of water.

The grist and water in the process of mashing are together called the "Goods."

It is essential to the success of brewing that the mash liquor* should have a temperature neither exceeding nor falling below certain limits which experience has proved are alone compatible with the extraction of the whole of the soluble constituents of the malt. This range of temperature extends from about 158° to 170° F., the precise degree most suitable in each case depending on the season of the year, the quality of the malt, and the nature of the beer to be brewed. As a rule, pale malt, that is, malt which has been dried slowly at a gentle heat, will not bear to be mashed at so high a temperature as malt which has been exposed to a quicker and stronger fire. To seek the reason of this, it must be considered that pale malt contains a large body of unaltered starch, as well as sugar and gum formed from the starch of the grain in the process of malting. Now, the sugar readily dissolves in water, however

* Water, in a brewery, always goes by the name of "liquor."

hot it may be; the gum also dissolves completely under the same conditions, only that it takes a longer time than the sugar. But when water at or near its boiling point is mixed with starch, a thick paste or jelly is produced instead of a thin fluid solution as in the case of sugar or gum similarly treated. A glutinous mass of this kind, unless it be strongly pressed or squeezed, will not pass through a strainer, and even then it will remain thick and opaque and refuse to assume the appearance or properties of a true solution. It is plain, therefore, that malt which contains much starchy matter is liable to "set," as it is termed, if water at too great a heat be poured on it. When this happens, the goods are said to be "locked up," and no wort of any value or quantity can be obtained from the mash, inasmuch as the unmanageable starchy paste encloses within itself the other constituents of the grist, and prevents the water from dissolving them out. On the other hand, high dried malt has had a greater portion of the starch originally present in the grain converted into gum by the action of the kiln fire. Such malt accordingly—amber or brown malt—is less abundant in starch than the paler kind, and for the reason just stated, will admit of a hotter mash liquor being used without the same risk of "setting."

Diastase.—In addition to the starch, which makes up the bulk of the kernels of unmalted grain, there is always present a small quantity of an important substance termed "gluten," * which binds or cements together the particles of the starch into a hard, compact, mass. During the operation of malting, or of natural sprouting in the earth, part of the gluten becomes changed into a white, soluble body, to which the name of *diastase* has been given. It is by the agency of this diastase that the starch of the grain undergoes transformation into sugar, a fitting, soluble, food being thus prepared by nature for the nourishment of the young plant about to emanate from the seed, until it is able to obtain food for itself from the soil and air by means of its developed roots and stem.

The maltster takes advantage of this natural process in order to obtain a supply of sugar as a material for the

* Glue, gluten, and its adjective, glutinous, evidently owe their similarity of name to the property they both possess of stickiness or adhesiveness.

production of beer or spirit. A little before the time when the future stem would burst the husk of the grain, and if allowed to grow would consume as food the store of sugar that had been formed within the seed, the maltster arrests further vegetation and prevents the sugar from being thus appropriated, and therefore lost to him, by drying the malt on a kiln at such a heat as experience has shown will render the diastase inactive.

As gluten is the source of diastase, it follows that malt must contain a less proportion of gluten than was contained in the raw corn. In the best malt about one part of diastase is formed for every hundred parts of starch originally present in the grain; but it is a remarkable fact that this small quantity of diastase is sufficient to effect the conversion of at least a thousand parts of starch into sugar. When an infusion of malt is made in hot water, the diastase dissolves as well as the gum and sugar which accompany it. The solution of diastase then immediately re-acts upon the remaining starch of the malt, changing it first into gum and finally into sugar. A second malting, as it were, thus takes place in the mash-tun; or rather the process which was suspended by the kiln drying of the malt is afterwards resumed and completed in the first stage of brewing.

Not only is the diastase of any given quantity of malt sufficient to saccharify the whole of the starch associated with it in the grain, but it has also the power to transform into gum and sugar a large additional body of starch derived from raw corn or other sources. It would appear, accordingly, an economical plan that brewers should make their grist to a considerable extent consist of unmalted barley, as the waste and cost of the ordinary operation of malting might so far be saved, and a saccharine liquor produced by adopting this expedient. All the experiments, however, that have hitherto been made in private brewing on the manufacture of beer from a mixture of malt and raw corn have been practically unsuccessful, the flavor of the product being unpalatable, and the liquor muddy and prone to an irremediable sourness. These disadvantages are of less importance as regards worts prepared for conversion into spirits; and some distillers consequently employ raw corn in their mash tuns on a large scale.

Still, it is probable that under the new revenue laws, which permit public brewers to employ unmalted grain in the making of beer, the experiments which will, no doubt, be made on a large scale to test the practicability of producing a sound and saleable beer from mixtures of malt and raw corn may show that the process is capable of being successfully and profitably conducted under certain precautions and conditions.

Mash Liquor.—Diastase, it should be noted, is "killed" or permanently deprived of its saccharifying property at the temperature of boiling water, and indeed even a little under this point the activity of the substance is somewhat impaired; while if the heat of the mash liquor is suffered to fall sensibly below 140° F., the diastase also ceases to operate with any effectiveness on the starch, very little change then taking place beyond the dissolving out of the ready-formed gum and sugar of the malt. As a necessary consequence in the latter case, the grist is imperfectly converted and exhausted, or a weak, turbid, infusion is obtained, however long the mashing may be continued; the worts refuse to clarify properly in subsequent stages of the process, and the matured beer is liable to become acid and ill-flavored. There is, of course less risk of injury to the diastase by the use of too hot a liquor at the commencement of mashing, unless water absolutely at the boiling point be brought into immediate contact with the bulk of malt, a thing which cannot well happen as the liquid invariably cools several degrees while passing from the copper to the tun, and suffers a further loss of heat during the time requisite for complete admixture with the meal. A medium temperature of about 165° F. is found the most suitable where malt of the ordinary pale description is employed, and at no period of the mashing operation should the heat be allowed, if possible, to fall below 145° F. High dried malt, as before observed, permits with safety and indeed with advantage, the use of a hotter liquor.

As to the quantity of water that should be used in extracting the soluble matter of the malt to the greatest advantage, all that is necessary as a general rule is to take care that no more shall be employed at first than experience has shown is sufficient to liquefy the whole of the malt, and

produce a mixture that shall have the temperature most favorable to the action of the diastase. It is evident that the water as it comes from the copper must be deprived of a large portion of its heat by contact with the mass of malt, the temperature of which during the ordinary brewing season is seldom higher than 50° or 55° F. Again, what is called the *specific heat* of ground malt, as compared with that of water, is such that for equal quantities of malt and water more heat is required to raise the malt to any given point than would suffice to give an equal elevation of temperature to the water. In other words, that amount of exposure to a uniform source of heat which would make a pound of water, say, 50 degrees hotter than it was before, would fail by several degrees in producing an equal effect on a pound of malt. For this reason, when hot water and malt are blended together, the actual temperature of the mixture, if tested without delay, would be found to be lower than the calculated mean or average temperature of the ingredients. A pound of malt at 50° added to a pound of water at 180° might be expected to have half the sum of the temperatures 50° and 180°, that is, 115°; but, owing to the specific heat of the malt, the resulting temperature proves to be about 105° only.

Immediately after the mashing has commenced, however, an effect of an opposite character takes place, occasioning an increase of temperature which more than countervails the previous depression, and raises the heat of the mash above the arithmetical mean. This result is due to the condensation or lessening of bulk that accompanies the act of the solution of the sugar of the malt in water, and the consequent liberation of heat. If, for example, a pint measure be filled with pounded sugar, and the contents be then emptied out and mixed with a pint of water, the bulk of the solution or syrup thus obtained will be considerably less than two pints or a quart—that is, than the sum of the quantities when separate. The sugar, in dissolving, contracts into a smaller space than it occupied as a dry substance, and at the same time a certain amount of heat is given out, owing to the intimate union of the two ingredients, which causes the temperature of the com-

pound to be sensibly higher than the average temperature of the sugar and water before mixing.

A similar result may be observed when strong spirit or sulphuric acid is diluted with water.

Since, then, the effect of condensation exceeds the effect referable to specific heat, as just explained, it follows that the heat of the "mash" when first formed will be greater than the computed or mean temperature; and it is necessary therefore to allow for this circumstance in adjusting the proper heat of the mashing liquor, especially where high-dried malt is used, which contains a larger proportion of readily soluble matter than pale malt, and leads accordingly to the development of more heat as that matter rapidly dissolves. By inattention to the increase of heat thus engendered, there is a risk in some cases that the mash may become so hot as to induce that most disastrous of all consequences to a brewer—the setting or locking up of the goods.

In practice it is found that, under all ordinary conditions, from $2\frac{1}{2}$ to 3 barrels* of liquor, if run from the copper at or about the temperature of 180° F., are sufficient to mash properly a quarter of malt, and so in protion for other quantities; the cooling on transit, the loss by the warming of the tun and by the specific heat of the malt, being all sufficiently provided for in the excess of 180° above 165°, which will probably be the initial or commencing heat of the mash. Of the total quantity of water above mentioned, only such a portion should at first be employed as will suffice to form a rather stiff paste with the grist. Two barrels per quarter are generally enough for this purpose. An effectual incorporation of the malt and water are more easily and certainly attained with a small than a large quantity of liquid, while the danger of "setting" is greatly diminished.

The rest of the liquor—a half or a whole barrel per quarter—should now be admitted at a somewhat higher heat, which will have the effect of rectifying the unavoidable falling off in the temperature of the mash, and reducing the whole to a thinner or more liquid condition.

The use of more water than is actually requisite for the

* A barrel contains 36 gallons.

full extraction of the soluble portions of the grist proves injurious and inconvenient, both by producing a weak or dilute wort, which always has a proneness to acetify or become acid with rapidity should there be any delay in the subsequent parts of the brewing process; and also by rendering it necessary to boil away the surplus liquid, at a great expenditure of time and fuel and at the risk of impairing the flavor of the beer, in order that the wort may be brought to the desired degree of concentration. It is probable, also, that when an unnecessary quantity of water is employed, the diastase, which is an exceedingly soluble substance, is so much diffused, and as it were diluted, as to have but little power of attacking the starch of the malt. As soon as the grist has been thoroughly blended with the mash liquor by the action of oars or machinery, the tun should be covered over in some effectual and convenient manner, for the purpose of preserving the heat of the goods and protecting the mixture as much as possible from the continued action of the air, which would otherwise induce acetification. The mash is now allowed to repose about two hours, without further stirring, in order that the diastase may have a full opportunity of exerting its saccharifying power upon the unconverted starch of the malt, and also so that any fine insoluble powder suspended in the liquid may gradually descend to the bottom of the vessel and permit the wort to be drawn off clear and bright.

Provided the requisite heat can be maintained while these operations are taking place, it is advantageous that the mash should not be disturbed for even a greater period than the ordinary two hours, but left at rest an additional hour or two, so that all the sugar which the malt is capable of yielding may be formed by aid of the diastase during prolonged digestion in a medium of the right temperature, and that the liquor may effectually clarify itself by standing. The only drawback to this mode of treatment is the danger of the goods *souring* when exposed for a single unnecessary moment to the atmosphere, particularly in warm weather. But, if the tun be kept closely covered all the time, and the original heat of the mash liquor have been so high as just to avoid "setting"

there will be no material alteration in the temperature of the goods for four or five hours, should the quantity of liquor not have exceeded $2\frac{1}{2}$ to 3 barrels a quarter, and the outer air be moderately cool. So long as these conditions are present, the slight unsoundness that may result from the formation of acid in the wort is much more than compensated by the increased richness of the extract obtained.

Various ingenious contrivances, called "Attemperators," have been patented for regulating the heat of mashes during protracted periods of infusion. The expense of these instruments, however, as well as the trouble of applying them and keeping them in good order has hitherto restricted their use to a few of the largest breweries. Besides, the more simple precautions first indicated are found to be quite as effectual on the small scale.

When the mash has stood a sufficient time the plugs at the bottom of the tun are removed or the stop-cocks are opened, and the wort is allowed to flow out. At first the cocks should be only partially opened or the plugs just loosened so as to avoid too strong a rush of the liquor, which would have the effect of disturbing the grains lying on the false bottom, forcing them into the perforations of the plates and thus either preventing the free draining of the goods or causing the wort to run off thick and foul. If it should be observed that the liquor is not clear as it runs from the tap, all that has been received in the underback should be returned gently on to the surface of the goods in the mash tun, and the same operation repeated as often as may be necessary, until a bright, transparent, stream issues from the vent-holes.

In the language of brewers, the draining off of the wort is called "setting the tap."

When it is ascertained that the wort is running clear the cocks should be opened to their full extent, so that the liquor may discharge itself as quickly as possible into the underback; for owing to the tendency of fresh, warm, wort to acetify, all unnecessary delay should be avoided at this stage of the process. Indeed, almost as fast as the wort runs off it should be conveyed into the copper, and there heated with hops.

If the first mashing has been well conducted, the heat of the liquor as it flows from the tap will not be much below 140° or above 150° F. If lower than 140°, it is almost certain that a poor extract has been obtained; that the malt has not been properly exhausted; and there is a risk of rapid souring. If higher than 150°, it is almost as sure that the original heat of the mash must have been so great as to produce some degree of setting of the goods and consequent loss. The "heat of the tap," as it is termed, serves therefore as a useful criterion of the success of the mashing, and is always a point of especial watchfulness and anxiety with brewers.

Another indication of successful mashing is the color of the wort as it runs from the tap, which should be nearly the same as that of the malt employed. The stream of wort should also carry a tough, close, head or froth, of pearly whiteness. When the heat of the mash has been too great, this froth has a brownish tinge, the depth of the color increasing with every degree of excess above the proper temperature in the mash tun. If, on the other hand, the malt has been mashed or maintained at too low a heat, there is but little froth, and that, light and easily blown aside; in this case also the wort will be thick and muddy, and liable rapidly to become acid and ill-flavored.

Brewers are further guided to a knowledge of the character of the mashing by observing whether or not the wort lets fall a white deposit on standing. A little of the running at the tap is received into a tall glass vessel, and put aside to be tested. If, after a few minutes, a whitish deposit be noticed at the bottom of the glass, it may be pretty safely inferred that the mash liquor was not hot enough to take a proper extract from the malt.

When the wort, on being rubbed between the fingers, feels slimy, it is considered a proof that the liquor was too hot.

There would seem to be no remedy for either of these defects, once the tap has been set, and any considerable portion of the wort drawn off.

As soon as the liquor begins to drain slowly from the goods, the taps are closed, and a fresh quantity of water from the copper or boiler introduced into the tun, and the

stirring machinery again set at work for fifteen or twenty minutes. The heat of the second mash liquor may, in general, be as high as 185° F. without any risk, as in the first infusion, of setting; since there can be but very little starch left in the grains, if the previous mashing has been rightly conducted; and nearly all that is now required is to wash out and remove as much as possible of the first wort as may be retained by the goods, and refuses of itself to drain off. It must be plain that the hotter the liquor is in this case, within allowable limits, the more effectually and quickly will it penetrate the grains, and with the agitation that is at the same time going forward enable nearly the whole of the dissolved matter to drain off when the taps are again opened.

As to the quantity of liquor that should be used in the second mashing, the ordinary practice is to pour over the grains about three-fourths of the bulk first employed. But the proportion must in a great measure be regulated by the degree of strength which it is intended the wort should possess before it is set to ferment; for in some cases it is desirable to limit the second affusion of water to the smallest quantity that will clear the grains of the remnants of the first extract, so that the entire body of wort may reach a certain density or strength without its having been necessary to concentrate the liquid by protracted boiling. Again, in other cases, it is often the object of the brewer to obtain a comparatively weak or dilute wort, from which beer of corresponding quality may be produced, and he accordingly uses an excess of water for this purpose in the second or subsequent mashing.

For ales and porter of medium strength, it is seldom that the second mash liquor is allowed to exceed two barrels a quarter.

As nearly all the soluble parts of the malt should have been exhausted by the first mash liquor, it is evidently of little use to keep the second liquor more than a short time upon the goods. An hour is generally sufficient to effect the object now in view; but after the stirring is complete the mash should be left to repose, carefully protected from the air by a cover, until it is judged that the suspended matter has quite subsided, and the same precautions as at

first should be observed in setting the tap; the wort also as it runs off should be removed to the copper with all possible expedition.

To ensure entire exhaustion of the malt, a third and sometimes even a fourth mashing is made at most breweries. But the sole effect of water poured over the grains must now be to wash out still more effectually the residue of the stronger worts, as there can be no conversion of starch at so late a stage, if the former parts of the operation have been well performed. Besides, diastase is so soluble a substance that in all probability the whole of it has been carried away with the first, or the first and second worts. It is supposed by some brewers that the unaltered gluten of the grain may continue to act slowly as a saccharifying agent in the absence of any portion of diastase proper, especially if a high temperature be maintained. For this reason numerous hot mashes are resorted to, and the goods left to stand a considerable time during each. But it would seem that whatever slight additional extract may be thus obtained, the attendant delay is so great an evil as to make it advisable to forego more than two, or, at the furthest, three mashings. The last products, moreover, have a coarse, raw, flavor owing to the suspension, or partial solution, in the liquors, of resinous and albuminous matters from the malt, which impart also a turbid or muddy appearance to the final worts. Such worts—that is the products of any mashing beyond the second or third — cannot be added to the previous liquors without injuring the quality of the beer, if a fine article is to be brewed. The common practice is therefore to keep these worts separate and convert them into table ale. Indeed, even the third wort is frequently set apart for the same purpose, or is held over, again heated, and used as a mash liquor in the next brewing.

The third mash liquor may with advantage have as high a temperature as 200° F.

It has, however, been lately recommended, that after the second mash the grains should be soaked and washed out with cold water; but to this it may fairly be objected that it involves a greater risk of souring than the ordinary process, and that the sudden lowering of the temperature would probably cause the grains to contract or shrivel, and

by the compression thus produced prevent the liquor from draining off.

In the third mash a barrel of water per quarter is the most that should be under any circumstances be used. A greater proportion would dissolve or bring away nothing of the least value from the grains, and unless the brewing be for very weak beer, the costly and objectionable expedient of protracted boiling must be resorted to to give sufficient concentration to the worts.

The quantity of wort obtained from each mashing is called by brewers a *length.*

Instead of making second and third mashes in the manner above described, it has long been the practice in Scotland, and is becoming also very common in other parts of the kingdom, to sprinkle the surface of the grains in the mash tun with hot water by means of a simple revolving instrument termed a *sparger*; and to let the liquor drain through the goods and run off by the tap with the last portions of the first wort.

The sparger is thus constructed.—A tin or copper tube of $1\frac{1}{2}$ or 2 inches' diameter, closed at the ends, and of sufficient length to extend across the mash tun, is divided into equal arms. A single row of holes is perforated in each of these, but on reverse sides. Both arms communicate by means of a small upright tube with a metal cup fixed above the centre of the principal tube or sparger. From this cup rises a short tube (A) terminating in a handle. Before using the sparger a wooden bar is placed across the mash tun, and an upright pin in its centre is passed through a circular opening at the middle point of the sparger and up the hollow tube (A) which enters the cup. This pin works in a pivot at the handle, and the whole serves as a frame on which the sparger may rotate. A stream of hot water at or about the temperature 180° is then caused to flow into the cup, and, as it escapes by the single row of horizontal holes on the opposite side of each arm of the sparger, the entire perforated tube is turned round by the resistance which the air opposes to the jets of water issuing from the holes. In this way the whole surface of the grain is continuously and regularly sprinkled with hot water.

A simple, but not so effective, a plan, is to place a per-

forated cover over the mash tun, and direct a stream of water upon it from the outside.

Sparging is begun, as a rule, almost as soon as the tap is set for drawing off the first wort; but in some cases, to guard against the wort being too much diluted, the sparger is not set until a considerable portion of the strong extract has run into the underback. As, however, the water from the sparging apparatus is gently sprinkled over the malt and descends but slowly through the mass of grains, there is little risk of the wort becoming too dilute as it runs off. Besides, when the greater part of the first wort is removed before sparging is begun, the grains are liable to be drawn into a compact state at the bottom of the tun which is with great difficulty penetrated by the sparge water, and the malt is therefore slowly and imperfectly washed out.

In order that the surface of the grains should not get dry, and cracks or channels be formed through which the liquor would escape without searching the malt, it is requisite that the process of sparging should be kept up without cessation, until it is found by testing the liquor at the taps, that no soluble matter of any value can be left in the malt. But no more water should on any occasion be employed than calculation shows is necessary for bringing the worts to the desired gravity.

Sparging has the advantage over second and third mashings as ordinarily performed, that it acts with great rapidity and exhausts the grist of all remaining gum and sugar, without dissolving and bringing away any of the objectionable resinous constitutents previously alluded to. It is certainly the best system that can be adopted, provided the first mash has been allowed to stand at the right temperature for a sufficient length of time, and where the object is to convert the whole of the wort into strong or fine ale. Under other circumstances, the old plan of subsequent mashings is perhaps preferable.

When sugar is used in brewing, all that is necessary is to dissolve it by itself in hot water, and add the solution to the worts in the underback or in the copper,—preferably the latter. Should greater concentration be desired the sugar may be mixed directly with the hot worts, instead of water.

However closely the produce of the first mashing may be drawn off, the goods in the tun will be found to retain from 34 to 40 gallons of wort for every quarter of malt brewed. A portion of this is displaced and set free by the liquor of the after-mashings or spargings, for which reason the second or third wort exceeds in quantity the water that has been used to produce it. When the last liquor is wholly and perfectly drained off, not more than from 24 to 28 gallons per quarter will have been left in the goods.

Malt of fine quantity absorbs rather less water than inferior kinds.

These facts, as ascertained by long and varied observation, supply a practical rule to the brewer by which he can estimate, with tolerable exactness, the amount of wort that he is likely to obtain from any given proportions of malt and mash liquor.*

SACCHAROMETER.—In order to adjust the gravity or strength of the worts to any desired or customary standard, according to the character of the beer to be brewed, recourse is had to the indications of a small floating instrument called the "Saccharometer," or sugar measnre. What this indispensable instrument does for the brewer is simply to inform him of the *weight* of his worts as compared with the known weight of an equal bulk of water, thus enabling him to judge of the quantity of saccharine matter which the water has extracted from the malt. It is evident that any liquid which holds in solution a solid heavier than itself, must weigh more and more per pint, gallon, or other measure, as it contains more and more dissolved matter in each such pint, &c. Pure water itself, at the temperature of 62° F., weighs 10lbs. per gallon. But a gallon of the weakest wort at the same temperature has a greater weight than 10lbs., owing to the fact that the weight in question, whatever it may be, is made up partly of so much water and partly of so much saccharine and such like matter, all of which is heavier bulk for bulk than water. That quantity of ordinary dry sugar, for

* The average loss or reduction of the original quantity of mash liquor by boiling, retention by the hops, evaporation on the coolers, and fermentation, will be stated in another part of this chapter.

example, which would just fill a gallon measure, weighs about 16lbs., whereas an equal quantity of water weighs only 10lbs.; and if the whole of the water be evaporated away from a portion of brewer's wort, the dry residue will be found to have very nearly the same relative weight.

If then, the brewer, knowing beforehand how much his worts should weigh per gallon or barrel when malt of good quality has been used and the mashing has been properly executed, will take the pains to cool a sample of the liquid to 62° and test the weight of a single gallon of it by means of a pair of scales or a balance of any kind, he will have, in the result he arrives at, not only a complete check on his mode of working and the producing power of his materials, but also a guide or index to the degree of concentration, or perhaps of dilution, to which the worts should be subjected in order to yield beer of the requisite strength and character. Thus, if 50° of gravity* had been fixed upon before the mashing as the strength the worts should possess on a given occasion, and the strength as ascertained by sampling the liquor in the underback, turns out to be only 45° of gravity, the brewer is made aware of the necessity of reducing the bulk of the worts by boiling until the strength becomes so much increased from loss of liquid as to indicate the desired point. On the other hand, it may happen that the gravity in the underback proves higher than was expected, in which case the quantity of the second or third mash liquor must be augmented above the usual proportion to reduce the strength as far as necessary; or if the mashes have all been taken, water must be added from the copper to produce the required effect.

Now, the operation of weighing with exactness a measured pint, quart, or gallon of wort, whenever the brewer wishes to determine how much heavier it is than water, would be so inconvenient and tedious in the midst of business, and unless both the measuring and weighing were made with great care and nicety, the result would in most

* For an explanation of this phrase see the remarks on page 33.

cases be so incorrect as to be of no value and calculated only to mislead. Instead of a measure and a pair of scales, the brewer avails himself of the indications of the Saccharometer, which tell him at once, correctly and without trouble, by how much the weight of a barrel of the wort under examination exceeds the weight of a barrel of water. The principle on which this instrument acts is very simple. According as the wort is heavier or lighter, the Saccharometer, as it floats in a sample of the liquid, rises or sinks, and, when it comes to a state of rest, shows, by a number marked on the side of an upright stem attached to the float or ball, and which number or division of the scale coincides most nearly with the surface of the liquid, what is the excess of the weight of a barrel of that wort over 360lbs., the weight of a barrel of water at 62° F.*

The instrument is adjusted so as to sink to the lowest point of the scale in water, and has such a range of indications as enables it to assay worts of all ordinary gravities up to the strongest that are ever brewed.

In the original construction, the Saccharometer after being adjusted to water is placed in worts or solutions of common salt—for it doesn't matter what gives density to the liquor, provided it does not corrode the metal—each stronger by a definite amount—as 1lb per barr.—than the preceding sample, and the point at which the edge of the stem cuts the liquid is marked upon the scale. The weight of a gallon or some other convenient bulk of the liquid is then determined by an accurate balance: from this the excess of the weight of a barrel above the weight of an equal quantity of water is easily calculated, and the final result in pounds is engraved in a line with the mark previously made on the scale.

A series of careful experiments having thus been per-

* The examples and illustrations given in this part of the text are adapted to the indications of the Saccharometer that has hitherto been employed by the generality of brewers, viz., that form of the instrument which expresses the relative weight or value of the wort in "lbs. per barrel." But the same principles apply equally to the action of the revenue Saccharometer indicating "degrees of gravity," as may be seen on referring to the chapter on the Saccharometer.

formed once for all by the maker,* it is evident that when the instrument is at at any time afterwards placed in a sample of worts it will float at or close to some point of the graduation which directly expresses the pounds of "gravity per barrel." When the brewer's Saccharometer indicates, for instance, 25 on the stem, what it signifies is, that a barrel of that wort weighs more by 25lbs. than a barrel of water does at 62° F.; or, in other terms, that the absolute weight of a barrel of that wort is 385lbs., that is, 360lbs. for water and 25lbs. for excess of weight in the wort.

If a gallon of the wort were actually weighed, it would be found that the indication of the Saccharometer was correct,—supposing of course that the instrument is in a state of true adjustment.

As worts when assayed are seldom at or near the temperature of 60° or 62° F., but are usually much hotter, and as it would be inconvenient and often impracticable to cool the sample to the standard point, a table of corrections for differences of temperature is furnished with each instrument, which shows the allowance that should be made in this respect according to the observed indication of the thermometer. The table in question is constructed from the results of experiment, and may be relied on as practically accurate.

The use of the Saccharometer, and of the table for correction of temperatures, will be more particularly described in another chapter of this work.

Boiling and Hopping.—The wort as it drains from the tun after the completion of each mashing is received in a vessel called the underback, and, as has been already remarked, should be thence removed as quickly as practicable to the copper and boiled with hops, the object of this expedition being to prevent the formation of an injurious amount of acid in the wort, especially the weaker runnings, by exposure to the air before undergoing the changes which take place in the copper. So impor-

* Although the above described method of graduating the stem of the Saccharometer is quite correct in principle and could not fail to furnish accurate results, yet, in practice, nearly all instruments are constructed by the much easier plan of making copies of a standard.

tant in its after-influence on the soundness of the beer is despatch at this stage of the process, that it would be well in all cases if the brewery were so constructed as to allow of the wort running direct into the copper from the mash tun, without the intervention of any other vessel. Except in very modern buildings, however, the plan adopted is to pump the worts up into the copper by steam or hand power.

Boiling with hops is considered to have a four-fold effect. 1. It concentrates, that is, reduces the liquid portion of the wort, and expels the contained air, the presence of which favors acescency or souring of the wort. 2. In the earlier stages of the heating it probably continues the conversion of starch into dextrin and sugar by means of the diastase present. 3. It extracts the substance (resin, bitter, oil, &c.) of the hops and diffuses it through the worts. 4. It coagulates or curdles the albuminous matter of the grain, and precipitates the greater portion of it, together with some of the mucilage, by the action of the "tannin" or astringent principle of the hop.

The albuminous matter just spoken of, which all fresh wort contains in greater or less quantity, consists chiefly of the dissolved gluten of the malt. It remains in solution until the liquid is heated to its boiling point, when it coagulates like the curdling of milk, and falls down in flocks as soon as the wort is allowed to rest. If much of this substance were suffered to remain in the wort, the development of acid would be promoted, the liquor would refuse to clarify, and the beer would rapidly become unsound. On the other hand, if the whole of the gluten or albumen be removed, fermentation cannot proceed properly in the wort, as it has been placed beyond doubt by the researches of chemists that yeast is incapable of propagating itself to any extent in a liquid devoid of the materials from which alone it renews its tissues; and these materials consist of the albumen and gluten above mentioned. Unless the yeast multiplies itself, fermentation stops, since the one action, as will be explained presently, is a necessary condition of the other. An *excess* of albumen, &c., is, therefore, all that the brewer should seek to separate from his worts by boiling; and it

is one of the many evils of protracted boiling that it leaves hardly anything in the worts from which the yeast can derive the means of its growth, and thus leads to languid and imperfect fermentation.

With respect to the matter which the boiling wort extracts from the hops added to it in the copper, it will be sufficient in this place to say,* that the principal substances which the hop yields when thus treated consist of a bitter principle, an astringent principle (tannin), and an aromatic volatile oil. A yellow powder, termed *lupulin*, adhering to the scales or bracts which enclose the nuts of the plant, contains the most valuable portions or chief virtues of the hop. This powder, or pollen, constitutes what is commonly known as the *condition* of hops; it may be separated in great quantity from good hops by beating and sifting, and is so much prized in brewing that its amount or abundance is regarded as the best test of quality.

The tannin of hops co-operates with the boiling to throw down the excess of albumen in the wort, and thereby assists clarification: the bitter ingredient neutralizes or disguises the mawkish sweetness of the infusion of malt, checks the tendency to acetification, and imparts tonic and keeping properties to the beer; the volatile oil is that which confers the characteristic odor of the hops; it impregnates the worts with its aroma, and acts in other respects somewhat like the bitter principle of the plant. Boiling also extracts a peculiar resin from hops which is believed to be the chief source of the narcotic effect of strongly hopped beer; but this substance is of course of no practical importance to brewers.

Coppers, in a brewery of any extent, are usually furnished with a dome, or rising cover, in which an opening, with a closely-fitting door, is provided, and on which a vessel called a *pan* is fixed. Cold wort or water is placed in this vessel and retained there while boiling is going on in the closed copper below, the steam from which passes through pipes into the pan, so that, in the course of the time requisite for the water or wort to boil, the contents

* A detailed account of the hop plant, and of the composition of its flowers and leaves as used in brewing, will be found in the next chapter.

of the pan are raised to boiling heat also. By this arrangement both time and fuel are greatly economized.

In some arrangements the steam from the copper, instead of passing directly through pipes into the pan, is prevented from issuing until it has gained force enough to raise a weighted metal valve placed at top. This valve opens outwards, and is so adjusted as not to permit the escape of steam at the ordinary boiling point of water (212°); but when the increasing pressure of the steam thus confined forces open the weighted valve, the additional heat accumulated in the liquid during the retention of the steam is carried off with the escaping vapour; the temperature of the remainder immediately falls to 212°, when the valve again closes the opening tightly till a further quantity of steam engendered under pressure pushes open the valve as before. The boiling is conducted in this manner as long as may be necessary, the steam being conveyed into the wort or water in the pan both for the purpose of heating the liquor and for condensing and retaining any of the aroma of the hops which would otherwise be dissipated in the air. The liquor, thus impregnated, is used in the subsequent mashings.

To prevent the burning or charring of the sediment and denser portions of the wort on the bottom of the copper, an apparatus called a *rouser* is generally employed in large breweries.

A vertical rod of iron extends to the bottom of the vessel, with chains loosely attached to the horizontal arms which branch off from it, and which are dragged round the bottom by machinery, in order to prevent the hops, or other thick or solid matter, from settling down, adhering to the metal, and burning. Another use of the rouser is to prevent the hops from lying in a mass upon the bottom of the copper when boiling has ceased, and plugging the discharge-cock so that the wort cannot be draw off. The bottom of a copper is usually of a concave shape, to increase the strength and favor rapid heating. In the smaller breweries coppers consist merely of convenient open vessels for boiling. The chief disadvantage of the open copper is the separation of a greater quantity of coagulable matter from the wort when it is boiled in a vessel with its surface

freely exposed to the air, and the undue impoverishment of the liquid in consequence;—for it has been found that the flaky deposit which is sometimes allowed to remain in the coolers at breweries as being of no value will, if boiled again in water, furnish a liquid capable of undergoing fermentation in the same way as the clarified wort itself. Another objection to the removal of more than an excess of albumen, as hindering the propagation of yeast, has already been pointed out. (See page 35.)

With close coppers, on the other hand, the risk of an undue precipitation of albumen is greatly lessened, inasmuch as air is not admitted, and as already stated, there is a considerable saving of time and fuel. The only drawback appears to be the slight elevation of the heat of the boiling wort above the temperature at which the liquid would boil in an open vessel: this has the effect of dissipating more of the volatile oil and aroma of the hop than would be lost at a lower boiling point, and also of decomposing more of the sugar and suspended starch, and thus communicating in a high degree a disagreeable, burnt, bitter flavor to the beer. But the contrivance of the pan just described arrests, no doubt, a large portion of the volatile oil; and, as regards the burning of the sugar and starch, any increased evil produced in this way may be restrained within small limits, simply by lessening the weight attached to the door or valve which closes the opening on the breast of the copper, and thus reducing the pressure of the steam.

The proportion of hops that should be used varies chiefly according to the strength or gravity of the wort and the character of the beer intended to be brewed—whether it is to be ordinary mild ale or porter in which there is no decided predominance of the hop flavor; or strong, keeping ale, &c., for home consumption, or pale ale, or bitter beer, with a preponderance of hops, and so on. The quantity depends also, in some measure, on the season of the year when the brewing takes place, as in warm weather more hops are required to counteract the tendency of the worts to acetify. Another circumstance that influences the extent of hopping is the climate which the beer may have to sustain. Export beer needs, as a rule, an ex-

ceptionally large amount of hops to enable it to bear without injury the heat of the country to which it is shipped. For the strongest ales and porters the customary proportion is about 1lb. to the bushel of malt or 8lbs. to the quarter. Ales, &c., of middling strength, such as ordinary pale and mild ale, require about 4lbs. to 4½lbs. per quarter: table beer about 2lbs.; Indian and export beers in general 12lbs. to 22lbs. per quarter.

In porter and stout, a stronger and coarser hop being commonly made use of, a less quantity suffices than ale of the same strength brewed with a milder hop would require.

It is important that the size or capacity of the wort-copper should be proportional to the amount of the brewing, or rather that the mash-tun and copper should bear a certain ratio to each other. As a rule, the mash-tun should be fully a third larger than the wort-copper; while for every quarter of malt mashed the copper should be capable of holding at least 140 gallons.

In a well-appointed brewery, working on anything like a considerable scale, there are always two if not three coppers—one exclusively for heating water in, the other one or two for the boiling of worts. Where one copper only is provided, much inconvenience and difficulty commonly arise in clearing the copper from the mashing liquor in time for the immediate reception of worts from the underback.

But coppers are very expensive articles, both as regards the original cost and the frequent repairs necessary. Hence in breweries of the smaller class, one copper is usually made to serve the purpose of heating the mash liquors as well as boiling the worts.

When the wort-copper is of sufficient capacity to hold at one time the produce of the successive mashings or spargings, the total quantity of hops may be calculated and added altogether in convenient portions at the commencement of the boiling; but if, as is usually the case, it is necessary to boil the different mashes separately, then the proportion of the entire quantity of hops that should be added to each wort in the copper is ascertained on the following principles:—

Suppose the brewing to be such as requires the use of 10lbs. of hops per quarter; that five quarters of malt are mashed; and that a full extract has been obtained. Suppose, further that the first wort is found to have the gravity of 150°, the second wort 72°, and the third 34°. How should the 50lbs. of hops be apportioned among the three worts?

As the total gravity is 256°, each degree of gravity corresponds to 0·195 lbs. of hops.

		LBS. HOPS.
The first wort, then, requires	150 × 0·195	=29
The second ditto	72 × 0·195	=14
The third ditto	34 × 0·195	= 7
	Total	50

When the total quantity of hops is regulated by a standard gravity or extract per quarter—as for instance the assumption that every quarter of malt will yield at least 90lbs. extract per barrel, and that for a particular kind of beer this amount of extract requires, say, 8lbs. of hops—and it happens that the actual gravity obtained reaches either more or less than the standard, then a calculation must be performed, if no tables are at hand, in order to find the proper proportional alteration in the quantity of hops. Thus, let the extract gravity prove to be 86lbs., instead of 90lbs.

We then say—

Grav.		grav.		lbs.		lbs.	
90	:	86	::	8	:	7·6	Answer.

about $7\frac{1}{2}$lbs. per quarter.

The stronger the description of hops used the longer the time requisite for a thorough extraction of the bitter and other properties contained in them. When the copper will contain the entire produce of the mashings, for the strongest and coarsest hops about two hours boiling will generally be necessary: for a milder or more delicate kind an hour or three-quarters of an hour may suffice; but in all cases great care should be taken not to boil too much or too rapidly lest a disagreeable astringency and bitterness, with little aroma, be communicated to the wort. To boil, as many brewers do, for three hours is highly objectionable and can in no case be needed; a heavy, resinous, bitter is sure to be extracted; the sugar, gum, and starch suffer

partial charring or decomposition, which increases the bitterness, and the volatile oil of the hop almost all escapes.

It is, however, absurd to suppose that any portion of the solid matter of the wort is carried away in protracted boiling. Some of the sugar, &c., will very probably be converted into other bodies, such as caramel, but the whole of the changed substance remains dissolved in the wort, as it is not in the least degree volatile, like spirits or essential oils.

When the worts are boiled separately, it is usual to boil the first about one hour, and the second about two hours; or, if three mashings are made, the second wort is in general boiled an hour and a half, and the third two hours.

It is also a frequent practice in these cases to boil the first wort about thirty or forty minutes before any of the hops are added, and then to continue the boiling for the remainder of the hour.

While the wort is being removed from the underback to the copper, the proper quantity of hops is weighed out, the solid cake picked into small pieces and thrown on the surface of the wort, if an open copper be employed, or at once mixed up with the liquor should a dome copper be in use. In the first case the floating layer of hops has the effect of excluding the air to some extent until the wort begins to boil, and any injury which might occur through decomposition of the sugar in the course of the heating up to 212° is thus prevented. The steam is allowed to penetrate the hops for some time before they are beaten into the worts, and by thus softening the fibre, is made to conduce to the readier and more complete extraction of the bitter and other constituents.

Many brewers do not add the hops until the wort begins to boil. Some wait, as just stated, half an hour or so after boiling has begun, and then add half the quantity they intend using, and in another half hour throw in the remainder. It is also an occasional practice to enclose the hops in netted bags, and to suspend these in the middle of the worts; when it is considered that the hops are sufficiently extracted, the nets are drawn up and allowed to drip into the copper.

In some instances the whole of the hops are added to the first wort; but if this plan be adopted it is usual to boil the first wort a shorter time, so that a portion of the bitter, &c., may be left unextracted, and available for the due impregnation of the second and third worts. The general practice, however, is to boil the produce of each mashing separately, with its own proportional quantity of hops, as above stated, and to clear the copper of the liquor before the next wort is admitted. In this case the second wort requires to be boiled for a longer period than the first, in order to throw down and remove the excess of albuminous matter which the *after-mashings* are apt, in an especial degree, to extract from the malt and carry with them to the copper, and also to exhaust the hops thoroughly, and effect a proper concentration of the worts.

The difference in the times of boiling, as adverted to on page 39, is thus explained.

It must again be remarked, that long boiling for the purpose of concentration only, is a great evil, which may always be avoided by regulation of the mash liquors as to heat and quantity.

As the aroma of the hop arises almost entirely from the yellow powder, or lupuline, care should be taken not to incur any loss or waste by breaking up the masses too much before putting the hops into the copper. Where dome or close coppers are employed, the proper proportion of hops is thrown into the vessel through a hole at the top; the door fitting this hole is then shut to and screwed fast to keep in the steam and force it through the wort in the pan.

Brewers judge that the worts are sufficiently boiled when the yellowish green pellicle or skin of hop oil and resin, which forms in a frothy state on the surface of the wort, disappears; and also when numerous light, fine, flocks of insoluble matter are observed to separate readily in the liquor, leaving the latter quite transparent between the floating particles, when a sample is examined in a glass. The usual method of testing this fact, which is called the "breaking" of the wort, is to dip a trial glass, or "proof gauge," suddenly to the bottom of the copper and draw it up. If flocks are collected in the

gauge while the liquor remains clear, it is considered that the wort has been boiled long enough. This test is called the breaking of the wort. As soon as it is seen to take place, the boiling should, as a rule, be stopped; but many brewers, intent upon communicating the utmost possible amount of bitter to their worts, do not slacken the fire under the copper for some time after "breaking" has begun. The practice is, nevertheless, an injudicious one, as by the protracted boiling certain disagreeable products, as well as an excess of bitter, are extracted from the hops. The sugar in solution is apt to get caramelized, or charred, and the surplus yeast which forms during fermentation becomes so much imbued with the redundant bitter of the wort as to be unsaleable for bakers' use.

The average loss by evaporation in the ordinary process of boiling may be estimated at about one-sixth or one-seventh part of the original bulk of the wort, although at several breweries where long boiling is practised, the waste frequently amounts to as much as one-fifth of the quantity pumped into the copper. The gravity increases at the same time in about the ratio of 5 to 4; so that every 100 gallons of wort are decreased on the average by boiling to 86 or 84 gallons; while if the gravity be, at first, say 32lbs. per barrel, it will at the end of the operation have risen to 40lbs.

Extract of Hops.—The opponents of boiling and those who aim at retaining the whole of the aroma of the hop in the beer have on several occasions endeavoured to form an "extract of hops," by heating the flowers and powder with water in covered vessels, so as to prevent the loss of any portion of the fragrant volatile oil. The digestion is continued long enough to ensure perfect exhaustion of all the valuable soluble matter of the hop: a proper quantity of the extract is added to the wort, and boiling dispensed with. But it does not appear that, on the large scale, this method is attended with much practical advantage, as the extraction of the hops is completely effected during the process of boiling, while by the use of a pan at the top of the copper, very little of the aroma is allowed to escape. Besides, the boiling with hops operates beneficially in clarifying the wort, and it is obvious that an

extract of the kind here alluded to could be easily adulterated.

Straining off the Hops.—As soon as boiling is judged to be complete, the wort and hops are conveyed from the copper into an utensil called the *hop-back*, which is simply a cistern with a perforated false bottom, intended to serve as a strainer, and a tap for letting off the clear liquor. Before opening the discharge-cock of the copper the contents are roused or stirred up to raise the hops in the liquor and thus cause the whole to pass off without obstruction.

In some parts of the kingdom, especially in Scotland, instead of using the metal strainer, a hair-cloth is stretched loosely across a square vessel, and upon this the contents of the copper are discharged: the liquid which runs through is not so clear as when it is made first to penetrate a thick layer of hops as in the ordinary hop-back, but the fine particles that accompany the wort in the former method are thought to act as a preservative to the beer by carrying down with them, when they subside upon the cooler, a greater portion of albuminous matter than would otherwise be the case, and thus effecting a greater clarification of the wort.

It is found that, on the average, every 60lbs. of hops retain about one barrel of wort. Most of this could easily be recovered by means of a press, but brewers generally prefer reserving the spent hops as they are left upon the strainer for a subsequent brewing of table beer, as, in addition to the bitter still remaining in them, they are capable of imparting a considerable amount of saccharine strength to the wort with which they may be re-boiled. In a few cases, after all the wort has passed through the strainer, a small quantity of hot water is poured upon the residual hops and the washings are added to the wort: but this method is seldom adopted.

Cooling.—As the clear wort runs from the hop-back it is usually at the temperature of from 200° to 206° F., and requires to be cooled rapidly down to between 62° and 56°* before it will admit of fermentation being begun in it, for yeast will not act properly except within certain limits of temperature.

* Not higher than 60° for ale worts or above 62° for porter.

It is essential that the worts should be cooled to the proper fermenting point with the utmost attainable despatch, so as to counteract the tendency to become acid which is always developed when a liquor of this kind is exposed for any length of time, even at a high temperature, to the atmosphere. The process of unaided or natural cooling would be much too slow for the purpose in view, unless the weather were extremely cold. Artificial means of hastening the process have, therefore, to be resorted to in almost every case.

An ordinary cooler is simply a spacious, shallow, oblong, cistern or tray, composed of boards jointed closely together, with sides rising a few inches high all round: the area or surface of the cooler should be considerable, in order that the wort may stand in a thin sheet or layer on the bottom, and thus the more quickly part with its heat. The vessel itself, and the objects in contact with it, as well as the air, abstract heat from the wort: a brisk wind playing upon the surface promotes evaporation and greatly expedites cooling. It is important that the bottom of the cooler should be quite smooth and level, so that no impurities may be retained by knots or unevenness in the boards; and there should be a slight inclination towards the end or side on which the worts are let off into the fermenting vessels. To ensure free access of air the cooler is usually placed at the top of the building, and open spaces left in the walls which enclose it are fitted with shutters arranged on the principle of a Venetian window-blind (louver boards), in order to create a draught. Still further to hasten the cooling, "fans," or "blowers," are frequently brought into use. The fans, consisting of two or more broad blades of metal attached at right angles to a vertical axis fixed in the cooler, are caused to whirl round at great speed, thus producing a considerable movement and current. Blowers are simply light iron paddle-wheels, working within a box closed at all parts except around the axle of the wheel, at which the cold air enters, and at the opening of a wooden pipe through which it is expelled. The effect of both fanners and blowers is to expose the surface of the worts to fresh bodies of air in rapid succession, each of which abstracts a portion of heat

from the liquor, and also to create a circular current in the liquid which makes it traverse the cooler equally.

It has been objected to contrivances of this kind, that the constant agitation of the wort which is produced by their action prevents the suspended solid particles from settling on the bottom of the cooler and thus clearing the liquor of impurities; but as it is the general practice of brewers to sweep the whole of the slimy matter that may deposit on the coolers into the fermenting vessels after the worts have run off, under the impression that such residue, consisting chiefly of unconverted starch and mucilage, is turned to good account in subsequent stages of the process by increasing the fermentable substance of the wort, the agitation caused by the fans or blowers cannot be of any moment, while it is certain that they contribute in a material degree to rapid cooling, and in close, foggy, weather hinder the stagnation of air over the wort, which is a fruitful source of acidity.

The souring that is apt without some such means as these to take place on the coolers is technically called *foxing*; it is accompanied by a disagreeable taste and odor, and the wort is not unfrequently interspersed with mouldy spots. When this effect happens during the time of cooling, it has a strong tendency to proceed in an increased degree through the rest of the brewing operation and to continue even while the beer is being consumed.

In the larger breweries it is now the practice to transmit the hot wort through a coil of metal pipes surrounded by cold water, a stream of which flows continually through the trough containing the pipes, but in an opposite direction to the wort. The water used for this purpose is obtained, if possible, from a deep well sunk on the premises, so that the temperature may be as low as circumstances will permit. In some cases, it is thought preferable to transmit water through the pipes and to fill the vessel which holds them with the wort. The two methods would seem to be nearly equal in point of efficacy, but the latter has the advantage of not introducing anything but water into the pipes, which consequently are more easily kept clean than if wort were made to circulate in them, while the wort itself is preserved

from the risk of contracting an injurious taint or acidity from contact with any of the decomposing matter that may have been deposited in a previous cooling.

Under either of these arrangements, the water which effects the cooling of the worts becomes, in consequence, so much heated as to enable the brewers who work on a large scale and mash more than once on the same day, to save some of the fuel that would otherwise be required for heating liquor in their coppers; or if the water used in cooling be not considered fit for mashing with, a portion of it can at least be turned to account in the scalding of vessels, and in cleansing purposes generally.

Several patent refrigerators of convenient shape and size, and of nearly equal efficacy, are now to be had at prices which, considering their usefulness to the brewer, the time they economize, and the waste and other serious losses they tend to obviate, can hardly be regarded as extravagant. It may confidently be affirmed, that, in the course of six months' ordinary work at a five-quarter brewery, the original cost of one of the medium-size new American refrigerators will be fully re-imbursed to the purchaser in the increased certainty and despatch of his operations, the waste prevented, and the soundness of his beer.

Coolers and a refrigerator are both occasionally used at the same brewery, the wort from the copper being first run on to the coolers for a short time to deprive it of some portion of its great heat before it is passed through the refrigerator. By this process a less supply of well or other cooling water suffices, and but little time is lost.

It is necessary that there should be at least two coolers when two kinds or qualities of beer are brewed from the same quantity of malt, and indeed in single brewings also where small beer is made. The coolers in this case are best placed one above the other, the hot wort being conveyed into the upper one first, and thence let down by a sluice after a short time into the other. Wooden coolers are open to the objection, that as they alternately expand and contract under the influence of heat, and the evaporation of moisture, the fibre or tissue of the wood becomes loosened, breaks down into a powder, and gets swept away

by the broom when the coolers are cleansed. The gaps thus formed gradually enlarge and permit the retention of a portion of the wort of each brewing, which, saturating the wood to a considerable depth, and being exposed to the action of the air, gives rise to decomposing products that taint every fresh body of wort with which they come into contact. Even if the substance of the planks resist the positive wear and tear thus occasioned, the air which enters the dilated pores of the wood and remains there, operates injuriously on the succeeding worts, by combining with the albuminous and mucilaginous matter, and producing a slight incipient fermentation known by a creaming of the surface, which rapidly engenders acid.

The best remedy for this evil seems to be a scrupulous attention to cleanliness, the frequent washing out of the floor and sides with lime water, and the practice of keeping the bottom covered with water after each cooling is finished and all the deposited matter has been removed. Coolers formed of cast-iron are free from almost every objection except that of the liability of the metal to corrode and wear away quickly, a result which may however be prevented, to a great extent, by coating the surface with tin or zinc, as in the so-called process of galvanizing. It has also been recommended that the separate pieces of iron should, previous to their being bolted together, be boiled for several hours in a dense saccharine liquid. This operation, it is thought, would so far encrust the surface with a hard, durable, film, as to render it practically impervious to moisture; and provided the vessel be swept down and dried when the final wort had run off, and not washed with cold water until a few minutes before the first worts of the next brewing were removed from the copper, there would be little danger of rust or corrosion.

It is doubtful, however, whether the protection thus afforded to the metal would have any durability, or would indeed have any of the efficacy ascribed to it; and it is certain that the experiment, although perhaps common at one time, has rarely been tried of late years.

Glazed tiles, made of felspar, have been recommended as a good material for coolers; but their greater cleanliness and durability are more than balanced by their low con-

ducting power as compared with metals, that is, such tiles would not remove heat from the worts with anything like the quickness of iron or other metals.

The wort, owing to the evaporation which takes place, becomes considerably reduced in bulk during the process of cooling. Thus, if the temperature at first were 206° and at the end 64°, the water which must have been evaporated to produce this degree of refrigeration would amount to nearly one-eighth of the entire quantity set to cool. On the average, the loss of liquid in this stage of the brewing operation may be said to vary from one-eighth to one-twelfth of the original volume of wort.

In the case of worts exposed on coolers, evaporation is most active in the spring and autumn, when the air is generally dry, and when a current plays over the surface. Under such circumstances a space of six or seven hours usually suffices to cool the wort to the proper fermenting temperature; but if the air be moist and there be no wind, the cooling, when unassisted by fanning, may occupy as much as from ten to fifteen hours.

It is here that the refrigerator comes to the aid of the brewer, rendering him almost independent of the influences of the weather and the season of the year, provided only he can command a good supply of cold water from some convenient source. The sole precaution necessary to be observed in the selection and use of refrigerators, is to see that the pipes are made throughout of one kind of metal only, and that they are not connected at any point with other metals. A neglect of this precaution may lead to electrical or galvanic action being excited in the current of wort circulating through or over the tubes, which result, if once induced, even in a very limited degree, is calculated to interfere materially with the regular fermentation of the worts, and to injure the fineness and keeping quality of the beer.

When coolers are used without a refrigerator, the wort, in summer, may be allowed to cool as low as the heat of the air will permit. As the greatest cold usually occurs shortly before daybreak, the wort at this time of the year should be set to cool during the night, so that the process

may terminate about the hour mentioned, and before the sun has gained any power.

In the colder seasons of the year—which are the best adapted for brewing—the wort must be removed from the coolers to the refrigerator as soon as the right fermenting temperature has been reached, as yeast will not act quickly or vigorously in too cold a liquid, and in consequence, an insufficient amount of spirit will be formed, the beer will have a heavy, sickly, taste, and will refuse to clarify or become bright.

The character of the malt that has been used appears to require some modification in the degree of cooling. Worts from high-dried malt should be cooled to a lower point than those from pale malt, for which reason it is best to brew chiefly from pale malt in the summer, as it will not be necessary in that case that the worts should be cooled below the ordinary temperature of the air.

FERMENTATION.—As soon as each wort has been brought to a temperature varying from 56° to 64° F., it is transferred without loss of time to vessels called "fermenting tuns," or "gyle tuns," for the purpose of being subjected to the action of yeast, and fermented down to the usual standard *cleansing* point for the description of malt liquor which the brewer wishes to prepare.

Cleansing, as will presently be explained more in detail, is the technical expression for racking off the wort from the great body of yeast into smaller vessels which are kept constantly full, and by thus checking the action of the yeast, removing the principal cause of the muddiness or turbidity observable in fermenting liquors.

As large quantities of wort evolve more heat during the progress of fermentation than small gyles,* provided the depth of the liquor in the tun, compared with the area of the vessel, and the other attendant circumstances, such as the warmth of the air, &c., be about the same in both cases, yeast may properly be added and fermentation induced at a temperature as high, perhaps, as 68° or even 70° F., where the brewer only mashes two or three quarters at a time.

The particular temperature at which the worts stand

* By the word gyle is generally meant the total quantity of wort available for fermentation, yielded in any one brewing.

when about to be mixed with yeast is termed the "pitching heat."

Gyle-tuns, or fermenting tuns, are large vessels of circular shape, made of seasoned wood, bound with strong iron hoops, and occasionally fitted with covers. In the latter case, man-hole doors are provided in the sides, which may be opened either to examine the process going on within, or to clean out the tuns. In some places a safety-valve regulated by a weight is attached, in order to prevent the risk of bursting, which otherwise might take place owing to the pressure of the accumulated carbonic acid gas when confined within a close vessel.

Instead of, or in addition to, the ordinary round gyle-tuns, vessels of rectangular construction, and technically called "squares," are in general use at the larger breweries. These vessels are usually left open at top, and are made of wood, iron, or slate, the latter material having much to recommend it on the score of cleanliness and coolness.

It is still an undetermined point among the best informed and most observant brewers, whether fermentation is most advantageously conducted in close or open tuns: but it is at least an established fact in chemistry that access of air is not essential to regular and perfect fermentation. Hence, to guard against the possible loss of small portions of alcohol, and the chance of speedier acetification, it would certainly seem prudent to adopt the plan of covering the tuns or squares while the yeast is in active operation. It is an objection, however, to the use of close fermenting-tuns that the beer prepared in them has often a peculiarly nauseous, bitter, taste, which lingers on the palate, and further, that the beer is apt to stupify, and produce headache. This evil appears to proceed from the intermixture of small portions of the yeast with the liquor, which the process of cleansing is unable wholly to remove if the tun has been kept closely covered during fermentation. Beer thus affected is said technically to be "yeast-bitten." In tuns open to the air this malady hardly ever occurs.

In all well-appointed breweries the fermenting vessels are furnished with an *attemperator*, or pipe, through which hot or cold water may be transmitted for the better regulation of the temperature of the liquor at any stage of the process.

It is customary to run the several worts from the coolers or the refrigerator into the fermenting tun at different times as soon as each has been sufficiently cooled.

A part of the entire quantity of yeast intended to be used is mixed with each portion of wort conveyed into the tun, and fermentation induced as quickly as possible. If necessary, small additions of yeast are afterwards made from time to time; but it is far better, when the first dose proves sufficient to carry on fermentation to the desired point with briskness and regularity.

Although some uncertainty still exists respecting the precise mode of action of yeast in decomposing a saccharine liquid, there can be little doubt, after the careful researches of modern observers, that brewers' yeast, or barm, is essentially a plant of the fungus species, or of the lowest order of vegetable life, which propagates itself and multiplies to an enormous extent when placed in solutions of sugar (such as sweet wort) containing also gluten or other available *nitrogenized* substances, from which the yeast may renew its own tissues and the contents of its cells. When these substances—gluten, &c.—are not present, as, for instance, where the liquid consists only of pure sugar and water, the yeast plant will excite fermentation to a certain extent, since it can obtain fitting materials for the structure of its cells; but it soon exhausts itself and subsides, as there is nothing in the liquid to supply it also with the elements of its *nutrition*. It may be considered, therefore, that the yeast grows partly at the expense of the gluten, or vegetable albumen, and partly at the expense of the sugar contained in the malt-wort; and that being in a state of great mobility or disturbance, it disposes the sugar of the wort to assume a similar condition. By the new arrangement or transposition of the particles of the sugar which is thus induced, compounds of a firmer or more stable character than that which sugar possesses, viz., *alcohol and carbonic acid gas*, are produced, the former of which mixes with the water of the fermenting liquid, while the latter, after dissolving to the extent of its own volume in the worts, rises in bubbles to the surface and escapes into the air.

It will now be better understood, why, as was stated in the earlier part of this chapter, the comparative scarcity of

nitrogenous matter in wort prepared from ordinary sugar renders it necessary to employ a greater quantity of yeast than in the fermentation of malt worts.

The difficulty of explaining the phenomena of fermentation arises from the fact, that the elements of the yeast take no part in the transformation that is effected—they do not combine with the sugar.

If the wort be very weak or dilute, fermentation will take place rapidly, and the greater part of the saccharine will be decomposed, but, owing to the large quantity of water present, the formation of acetic acid at the expense of some of the spirit first produced is greatly favoured, and the soundness of the beverage is impaired.

If, on the other hand, the wort be at first of a very high density, it is necessary to use a great deal of yeast, which is objectionable for the reasons previously pointed out, and the large body of alcohol generated in the liquor, has the effect of suspending fermentation at an early stage, by arresting the action of the yeast. Extremes of temperature have also the power of suspending the action of yeast, although the property of again exciting fermentation when the temperature is reduced or raised to the requisite extent, is not thereby necessarily destroyed. It has been found in several experiments, that a heat of 187° F. puts an effectual stop to fermentation

Within two or three hours after the addition of yeast, the wort enters visibly into fermentation, provided the temperature does not fall much below 50° F. A cream-like froth, consisting of minute bubbles of carbonic acid gas, forms on the surface of the wort, as soon as the liquid has become saturated with the gas previously generated.

In a little time, larger bubbles are disengaged, and when fermentation is at its height the evolution of gas is so energetic that the contents of the tun are frequently urged to overflow by the tumultuous intestinal motion of the liquid.

During the process there is a gradual, though by no means uniform, rise of temperature, and just before the ordinary cleansing point is attained the heat is occasionally found to be as high as 90° F., or about 25° above the average temperature of the wort when first set to ferment,

The usual signs of a good fermentation taking place, are 1st—the appearance, as just stated, of a mantling, creamy, froth, around the edges of the gyle-tun, which slowly extends over the entire surface of the liquid. 2nd—the formation by degrees of a curly head of yeast, which also should cover the surface. This appearance is called by brewers the *cauliflower head.* If, instead of resembling a cauliflower, the head of yeast curls in broad flat flakes, it may be inferred that the wort is not fermenting satisfactorily. Up to this time there should be very little smell from the liquid. 3rd—the head changing to a light, rocky, appearance, of a fine, brownish, colour. The height of the head is now generally about two or three feet above the surface of the wort. 4th—the dropping of the light, yeasty, head, by as much as three or four inches, and the exhalation of a pungent aroma from the tun. 5th—the rising of the head in a close, firm, mass, which breaks into a rapid succession of minute air-bubbles on the top. If the fermentation has gone on healthily so far, the head will now continue rising and puffing out gas, until it is thought time to arrest further change by cleansing into smaller vessels. A sharp, pleasant, aroma should be evolved from the wort through all the latter stages of the process. This odor is commonly styled "stomach" by brewers.

The preceding are the most striking characteristics of a sound and regular fermentation. By the marked absence of any of them, or by a sensible change in their manifestations, the brewer may conclude that something has happened amiss, and that unless a prompt remedy be applied, the result is almost certain to be unsatisfactory.

In the chapter specially devoted to fermentation, the irregularities most liable to occur during this process, with the appropriate treatment, will be concisely described,

In no part of the operation of brewing is there a greater diversity of practice than in the mode of conducting the fermentation of the worts; none appear to follow exactly the same routine even when preparing malt liquors intended to possess the same strength and quality, and under circumstances nearly identical; some using very low "pitching heats," others, very high; some cleansing at an early stage, others, not until a late period; some skimming off

the head almost as fast as it rises, others, beating it into the body of the liquid; all pursuing a different course in the management of some of the principal or minor details of the process. In consequence of this variation of practice, hardly any two breweries, excepting, perhaps, a few of the large houses in London, Burton, &c., produce beer precisely similar in point of density and flavour; nor is the manufacture of the same firm always uniform in these respects. It is no doubt, in a certain degree, necessary to suit the taste of each locality, and to gratify the long-established preferences of the majority of consumers. But the vastly increased demand throughout the country for the Burton ales, and London and Dublin porter, shows that considerations of price and the influence of local ties cannot prevail against the general desire for an article of uniformly fine condition and agreeable flavour.

The proportion of yeast added to worts of medium gravity seldom exceeds anywhere 2lbs. per barrel, provided the weather is not unusually cold and it is not the object to carry fermentation beyond the customary point. If the yeast be old or stale, a large quantity of it must be used, since it becomes inert by keeping: the amount must be increased also if high-dried or patent malt be mashed, as the elevation of heat on the kiln leaves less readily-fermentable matter — especially gluten—in the malt: the stronger the wort when run into the gyle-tun, the larger the dose of yeast requisite to ferment it properly, although the direct contrary of this was long believed by brewers; the same is also the case if either the liquor itself or the outer air be colder than ordinary.

Worts prepared from sugar need, as has been observed in former parts of this chapter, a considerably greater proportion of yeast than malt worts.

As a general rule it may be assumed that if 1lb. of good, fresh, yeast be added for every 10lbs. of original gravity in the gyle-tun, then for every degree of increased temperature in the fermenting wort there will be an accompanying diminution of gravity to the extent of about 1lb., as indicated by the Saccharometer. The cause of this change of gravity will be fully explained a little further on. The only variation from this result is where

the worts are kept fermenting a very long time, as is still the practice in some of the older breweries. The yeast used in pitching the tuns should always be that which accumulates in the troughs or stillions* during the completion of the cleansing process, and not that which is skimmed, during active fermentation, from the surface of the wort in the gyle-tuns or squares. The latter is seldom so energetic as the stillion yeast.

It was formerly the custom to make frequent changes of the yeast, that is, to obtain fresh supplies on every few occasions from different breweries. This was done under the impression that the same yeast as it multiplied itself in successive brewings at one place was apt to become weak and ineffective. It was also thought that any unsoundness or incompleteness in the fermentations was principally due to the yeast employed. Hence constant changes were resulted to as the best remedy. But it is now ascertained that so long as fermentation goes on from time to time briskly and healthily there is no benefit, but rather a danger, attendant on this practice: and, unless after a long cessation from work, yeast of the same stock is used, without the least disadvantage, for several years continuously by the leading brewers. It is necessary, however, that the stock of yeast should be kept in a very cool place, and carefully protected from mechanical injury.†

The quantity of yeast intended to be mixed with the produce of each brewing should be determined by weight and not by measure, as yeast is an article of such uncertain quality and composition as sometimes to vary in weight several pounds per gallon.

It is advisable, particularly when using strange yeast, to mix it with a small portion of worts at a temperature of from 80° to 90°, and to let the mixture stand until it is seen to be rising and entering into active fermentation, before adding the preparation to the worts in the gyle-tun.

The object of skimming off the head of yeast as fast

* Stillion is the technical word for the long wooden troughs in which are received the overflowings of the yeast when placed in small casks to complete the fermenting process. See the text a little further on.

† The particles of yeast, when bruised or flattened by strong pressure, lose their power of producing the vinous fermentation.

it rises to any height upon the surface of the worts, is not only to abate the violence of the fermentation, but also to remove a peculiar and disagreeable bitterness with which the first portion of yeast is impregnated, and which, if not thus carried away, would communicate its flavor to the body of wort in the tun. With most brewers, however, it is the practice to skim off merely the top of the swelling head of yeast, and to beat down the rest and diffuse it through the liquid. This is more common in the brewing of mild ales than porter, as a greater degree of fermentation is usually required in the latter case, while the bitterness is not objectionable. Ale, on the other hand, must retain a sensible degree of sweetness to please the general taste—pale ale and bitter beer perhaps excepted. Hence, the fermentation needs to be checked in the course of the process, to prevent too much saccharine from being decomposed, and this is effected most easily by skimming off, at intervals, the light head of yeast.

In order to regulate at pleasure the heat of the fermenting wort, so as to stimulate the process when it is languid or repress it when violent, what is called "tempering pipes" are, in the more extensive breweries, placed along the interior of the tun. A supply of hot water or steam, or of cold water, as occasion may require, is made to circulate through these pipes, and in this way the temperature of the wort is brought under the control of the operator.

As to the period of fermentation, it would appear, from the best modern practice, that the shorter the time the worts are kept in the gyle-tun under the action of yeast at ordinary temperatures, the less is the risk of any injury accruing from changes of the atmosphere or other fluctuating circumstances; and that the beer produced from worts which had undergone a moderately rapid and continuous fermentation, gain in fulness or body as they become older, and generally retain their soundness to the last, while slowly fermented beers have, as a rule, a tendency to contract a large amount of acidity at an early stage and to lose fulness and richness of flavor.

It should be remarked, however, that the evils of protracted fermentation are confined to the method of working

adopted in this country, and are not at all liable to occur where the entire fermentation is carried on, as in Germany or Bavaria, at extremely low temperatures in deep, underground vaults. Throughout Bavaria, the worts, after being boiled, hopped, cooled to at least 50° F., and mixed with yeast, are placed in large, shallow, pans, in a cool, subterranean, place, where there is a nearly uniform temperature at all times of from 45° to 50° F. A slow, scarcely-perceptible, fermentation then takes place, which does not terminate or is not checked for several weeks, and indeed occasionally not for several months. During this process the gas (carbonic acid) is evolved only in very small bubbles, and the yeast settles at the bottom of the vessel instead of rising continuously to the top as in the quick, warm, fermentation practised in England. It is noticeable that beer thus prepared retains hardly a trace of gluten or yeast, and admits accordingly of being kept for years without turning sour. Such beer, moreover, is more abundantly charged with carbonic acid than that obtained by the quick process, because owing to the much lower temperature and the more gradual development of the gas, it is able to retain a greater quantity of the latter.

Fermentation of this kind is termed, "bottom fermentation," and the yeast which subsides, "bottom yeast," in distinction to the "surface fermentation" and "surface yeast" of the English system.

The ordinary or surface yeast of our breweries multiplies in enormous quantity as fermentation proceeds, whereas in the Bavarian method there is a much less production of the precipitated yeast. The cause of the yeast rising to the top of the liquor, during the quick, English, process, is the buoyancy of the gas which forms so abundantly and rapidly at high temperatures and carries the particles of yeast to the surface and raises them in a frothy mass above it. Yeast derives the chief portion of its structure—the fluid contents of its cells—from the gluten of the malt, which is dissolved in the course of the mashing, but is separated in an insoluble form as fermentation advances. As some portion of sugar and gluten is left in the finished beer, however far it may have been at first fermented, a slight, gradual, secondary

fermentation takes place whilst the beer is maturing. But the whole of the gluten is not removed even by this second fermentation, and hence beer thus prepared is liable to undergo a still further change when exposed to the air. The spirit in the liquor is then acted on by the albuminous matter present, vinegar or acetic acid is formed at the expense of part of the alcohol, and the beer becomes "hard." But, as has just been explained, the gluten is wholly removed by the Bavarian method in the course of the slow, gentle, fermentation; no secondary fermentation takes place, and the beer in consequence preserves its freshness and soundness to the last drop, even when in free contact with the air.

There is, however, an insipidity, or a want of characteristic flavor, about Continental beers generally, which makes them unpopular in this country, notwithstanding their sprightliness and soundness. Besides, in London or any of our large towns, the expense of providing a sufficiency of deep cellar-space beneath the breweries, in which an equable temperature of from 45° to 50° F. might be ensured all the year round, would be much too great for persons of moderate capital to incur, while the price of the beer would necesarily be enhanced above its present amount by the length of time required to complete its manufacture.

For ales of the ordinary medium strength as consumed in England, the process of active fermentation in the gyle-tun is seldom extended beyond from twenty-eight to thirty-six hours. By this time, provided there has been no irregularity in the action of the yeast, about half the saccharine matter of the worts is transformed into alcohol and gas, and the liquor is considered fit for cleansing. Another common test of the proper point of fermentation having been reached is the amount of decrease in gravity. When about two-thirds of the original gravity is found to have disappeared, or when the temperature of the worts has risen to 74° or 75° F., whether the gravity has fallen to that extent or not, it is the practice with most brewers to commence the cleansing. Light, bitter beers and porter are allowed to remain in the tun under the full influence of the yeast for a considerably

longer period,—that is, until the usual "sending out" strength for liquors of that class has been attained within one or two degrees, a slight margin being left for the effects of the slow fermentation subsequent to cleansing.

In the earlier stages of the fermenting process, the yeast which rises to the surface and is usually skimmed off, falls back after a little time into the liquid state. As soon, however, as fermentation is complete, the frothy head remains in the same puffed-up condition fcr a considerable time, and possesses a thickish, tenacious, consistence.

It should be observed, that when worts are mixed with a full proportion of fresh, active, yeast, and set to work at a high temperature, fermentation is apt to proceed rather too violently, unless the rising heat be checked by means of the tempering pipes already described (page 56), and in consequence, the gluten of the wort is only imperfectly removed, and from the secondary fermentation, or "fret," thus occasioned, the liquor cannot be brought to clear itself thoroughly.

On the other hand, the continuance of too low a temperature after the tuns have been pitched, induces that viscid, oily, condition of the worts known as *ropiness,* and in addition, the peculiar bitter known as the "yeast-bite," (see pages 50, 51), frequently infects the entire contents of the gyle.

The object of beating part of the newly-formed head of yeast back into the liquid, as is the custom with many brewers, is to stimulate, when necessary, the tardy action of the ferment, and thus procure a proper elevation of the temperature, by which those almost incurable maladies, ropiness and yeast bite, may possibly be arrested.

Due attention to the quality of the yeast employed, and a careful regulation of the pitching heats, seem, however, to be the only sure preventives of a languid and sickly fermentation.

After the first vigorous working of the yeast has ceased, and the gravity is found to have diminished to the desired extent, the wort, if suffered to repose, would soon clarify itself by the subsidence of all the suspended insoluble matter to the bottom of the vessel. A new series of changes would then occur; the liquor would rapidly become clouded

or turbid, a small quantity of gas would escape, the heat would increase, and in a short time vinegar would be formed abundantly at the expense of the alcohol of the fermented worts, thus spoiling the produce as a beverage.

To prevent these injurious changes, and to retain the soundness and other desirable qualities of the beer, the process of cleansing is now resorted to; but before describing the mode of conducting that operation, it is necessary to premise a few words with respect to the nature and meaning of "attenuation."

Attenuation.—This expression literally signifies a making or a becoming *thin*, and is very appropriately used to denote the altered condition of worts as fermentation advances, and the consequent fall of gravity reduces the proportion of solid matter originally present, which is in part replaced by the light, thin, body called alcohol.

It will readily be understood, that as the saccharine constituents of the wort become resolved by the action of the ferment into carbonic acid gas, and alcohol or spirit, the original density of the liquid which depends on the quantity of sugar dissolved in it, must be affected both by the escape of the greater portion of the gas, and the presence of the alcohol generated. The alcohol is considerably lighter, bulk for bulk, than water, and the gas which has disappeared represents a loss of so much of the solid matter of the wort. If *all* the gas and the alcohol produced were collected apart and weighed—as they could be by suitable means—their united weights would *exactly* equal the weight of sugar decomposed; but in reality the bulk of the gas is withdrawn, while the alcohol does not weigh nearly so much as the water it displaces. There can be no difficulty, therefore, in conceiving how it is that fermenting or fermented wort has a lower gravity than before it began to ferment. The degree of attenuation is shown by means of the Saccharometer in the same way as in testing the original gravity of the worts, the difference between the two gravities indicating the extent to which the liquor has attenuated.

However far fermentation may be pushed, part of the saccharine matter originally present will always remain undecomposed—although not unaltered in character—at

the end of the process. It is ascertained, that on an average not more than four-fifths of the solid constituents of the wort obtained from malt or sugar can be made to undergo decomposition into alcohol and carbonic acid, the remainder proving in most cases quite unfermentable, even after all the alcohol has been removed * and fresh yeast added. In the present work it is not requisite to explain the chemical reason of this well-attested fact, which is of no importance to brewers, as they invariably stop the fermentation of their worts long before the point at which it would naturally cease to act, in order that sufficient fulness or sweetness may be retained in the beer, both to please the public taste, and also for the purpose of providing a material on which any residuary gluten may continue to act without endangering the soundness of the beverage.

CLEANSING.—The chief object of this process has already been stated (page 49). It should now be added, that by the division of the entire body of the wort into smaller portions, the temperature of each becomes rapidly lowered, and the progress of fermentation checked in so great a degree that it cannot again rise to any considerable height, since the increase of heat in a fermenting liquid is proportional to the bulk or quantity of the worts. Thus in small brewings the principal difficulty is to maintain a sufficient temperature in the gyle-tun; and hence one of the secrets of the more uniform and generally successful results of operations on the large scale.

The ordinary practice in cleansing is to rack off the contents of the gyle-tun into a series of smaller vessels, placed with their bung-holes or orifices upwards, or a little inclined, so that the yeasty matter brought to the top by the buoyant gas still generated in the liquor, may pass over into a receptacle, and thus promote complete clarification; so long as fresh particles of yeast continue to be formed, the worts will remain thick and turbid. The vessels in question are kept constantly full to prevent access of air, by pouring in as needed a supply of fresh liquor, which usually consists of well-fermented beer of the same description. The casks are ranged side by side on a long

* The presence of a certain amount of alcohol in a saccharine liquid arrests further fermentation.

trough (stillion), in the bottom of which are holes with conducting pipes attached: these serve to convey whatever portion of the escaping yeast falls back into a liquid state in the trough, to a reservoir whence it may be returned into the casks on the stillion. The filling of the casks is usually performed by a man who carries a leathern hose or tube proceeding from a vessel which contains sound, bright, ale. In the end of the hose are fixed a metal pipe and cock: by inserting the pipe into the bung-hole and opening the cock, a sufficient quantity to fill the cask is admitted: the floating head of yeast within is thus displaced and removed by overflow into the stillion.

At several of the large breweries instead of employing manual labor, an ingenious mechanical contrivance is used to effect the same object; the casks are all caused to communicate at bottom by a pipe through which they are filled to an equal height as fast as they discharge the yeast.

As soon as fermentation appears to have ceased, no more yeast, or but very little, being thrown off, the casks should be tightly closed or bunged down, so that the carbonic acid gas which still forms in small quantity may be retained in the liquor, and thus impart liveliness and sharpness of flavor. It is important, however, that each cask while kept in store should be occasionally examined and vent given, if the pressure of the gas should be greater than the cask is likely to withstand.

It must be always borne in mind, that the operation of cleansing, by dividing the bulk of the worts into several small quantities, has the effect of lowering the temperature and reducing the activity of the fermentation so much, that should the contents of the gyle-tun not have attenuated sufficiently at the time of racking, very little further change of density can subsequently be made to take place, and the finished beer will in consequence retain more body or sweetness than was desired.

To obviate this, it is a common practice with brewers before commencing to cleanse, to rouse the worts briskly, so as to bring up the yeast that may have fallen to the bottom of the vessel, and to diffuse it through the liquor as a last stimulus to the fermentation. With the same object, especially if the weather be cold, others add a

small dose of fresh yeast, and stir it well into the gyle. The check shortly after given by the racking-off is thus, as it were, sought to be moderated, and the wort aided to carry on a sensible fermentation in the casks, up to the point at which all cause of turbidity would be removed. But it is a better plan to defer the cleansing until the attenuation is so low as just to leave enough saccharine matter in the beer to give rise to a slow, gradual, evolution of carbonic acid, and thus preserve the freshness and sprightliness of the drink without diminishing the amount of body it should possess, or allowing it to *fret*, and become acid from the retention of an excess of gluten. No general rules can be laid down which will enable the brewer to attain this end independently of the exercise of judgment and close observation on his part. Experience of past results under varied circumstances, and the constant, intelligent, use of the Saccharometer as attenuation advances, are here the best, if not the only safe, guides to success.

The larger brewing firms have of late adopted improved methods of effecting quick and thorough cleansing; but there is not space to describe the details in the present work.

The light, floating, head, which the gas forces out at the bung-hole of the vessels in the stillion, does not carry off the whole of the yeast formed in the worts. A portion too heavy to be extracted in this manner remains in the liquid, and after a time sinks to the bottom of the cask, constituting what are called the "dregs" or "lees." It is by the subsidence of such matter, as well as by the exit of the more frothy particles at the top, that the liquor finally becomes bright and clear.

Cleansing is greatly influenced by the quality or composition of the water employed in mashing. It was formerly believed that soft rain, or tolerably pure river water, was the best for brewers' use, as producing the greatest amount of fermentable extract from the malt. But it is now well known that well or spring water of a certain degree of hardness arising from the presence of small quantities of lime salts, not only exhausts the goods as completely as the softer kinds, but through the reaction

of the lime compounds on the mineral matter contained in the malt, causes a precipitate which as it subsides carries down with it the suspended mucilage and other impurities of the wort, leaving the liquor above as fine as can be desired. Owing to the hardness of the well water at Burton, it is rarely found requisite to adopt any artificial means for clarifying the ales brewed there.

In the slow fermentation process, such as is practised by the Scotch brewers generally, cleansing into smaller vessels is unnecessary. The worts being kept from six to twelve days in gyle-tun at a regulated temperature, as soon as it is judged proper to check attenuation, the head of yeast is allowed to remain on the surface of the liquor, and cold water is passed through the attemperating pipes to reduce the heat. In the course of two or three days the wort fines itself, and is fit for racking direct into the sending out casks. These are left open for a day or two, and are then bunged down. By raising the end of the delivery-pipe an inch or so above the bottom of the vessel, both the upper and under yeast may be wholly left behind when racking from the gyle-tun.

In England, where as a rule the quick fermentation plan is followed, cleansing is an essential part of the operation of brewing. The worts, as before observed, are fermented to a greater extent than in Scotland, and at a higher temperature; the heat consequently attains its maximum in twenty-four to thirty-six hours, and must then be checked by dividing the gyle into small portions.

When fermentation is completed according to this system in casks or "rounds," the beer, if not intended for immediate consumption, is at most of the large breweries emptied into the yeast trough which has previously been cleared out to receive it, and is thence conveyed into huge cylindrical vats fitted with covers. After being stored in this manner, the beer still undergoes a slow fermentation, gradually developing gas and forming alcohol at the expense of the sugar present.

It was formerly the practice to keep immense stocks in these vats until the beer "ripened," that is, lost most of its sweetness and mildness, and acquired an acid flavor.

Good, hard, ale was then the favorite drink. But now-a-days the public taste is greatly changed, fresh, mild, malt liquor being in universal demand. Such beer is often consumed within six weeks of the time of its manufacture.

Ale and porter intended for bottling is usually sent out in the casks in which cleansing has been performed, as in this case a considerable proportion of saccharine must be left unattenuated to feed or sustain the subsequent fermentative action by which alone the frothing condition of bottled liquors can be produced.

In order to keep up a temperature sufficient to ensure expeditious cleansing, it is sometimes necessary to warm, by artificial means, the room or cellar in which the casks are placed; for this purpose the most common expedient is to maintain fires in small portable grates in the cellar, should the weather be very cold at the time.

It will readily be understood, that if attenuation be carried so far before cleansing as to decompose nearly the whole of the saccharine matter in the worts, or if it be allowed, as in the process of the distiller who has a different object in view, to proceed unchecked to the furthest extent of which it is naturally capable, there will be nothing to prevent the formation of a large amount of acetic acid in the liquor, with its accompanying loss of spirit, and the spoiling of the beer. To guard against such a consequence, therefore, active fermentation must be restrained at some point short of that at which it would complete itself, if not interferred with either by the process of cleansing or by moderating the temperature and ceasing to mix up the newly-formed yeast in the gyle-tun. On the other hand, should cleansing be too early resorted to, or should the slow fermentation process be insufficiently prolonged, an undue amount of mawkish sweetness or fulness will be retained, the worts will not readily clarify, and the beer will be wanting in gaseousness and alcoholic strength.

It is a great advantage of the system of completing fermentation in the gyle-tuns or squares, that it enables the brewer to exercise a close control over the progress of the operation, and to check it with ease and certainty at any desired point; whereas, by transferring the worts into

casks and finishing the process there, all power of noting and arresting the further changes that take place is lost. For this reason, beer prepared by the cleansing system is rarely uniform in strength or quality, and is liable also to be sent out in bad condition.

The average waste during fermentation and cleansing may be estimated at about six gallons per quarter of malt brewed.

Fining or Clarifying.—From various causes, some of which with all the care that may be exercised are beyond the control of the brewer, beer will occasionally remain muddy after it has gone through the cleansing operation and been allowed to rest for a short time in order that it may clarify itself by the subsidence of any floating particles. Unfavourable weather, insufficient boiling, hurried fermentation, and the use of damaged malt and soft water, are the principal sources of the want of transparency, which is often so persistent and difficult to remedy in new beers. In most cases, however, if when cleansing has been carried as far as practicable on the stillions, the liquor be kept in closely-covered vats or casks, tightly bunged down, for a few weeks, fining will spontaneously take place. But as the necessary delay is productive of loss to the brewer through part of his capital remaining idle, and his vessels and storage-room being occupied during the period required for the natural clearing of the beer, and as besides there would be danger of souring in the interval, he has recourse to an agent which greatly expedites the process of clarification and accomplishes in a few hours that which might otherwise have consumed an equal number of weeks.

The "finings" commonly made use of consist of a solution or a semi-solution of isinglass (fish-gelatine) in sour ale, vinegar, or refined acetic acid, the last-named being the best and, on the whole, the cheapest solvent, as it acts promptly and effectually and a small quantity suffices. Owing, however, to the convenience of having on the premises, or of easily preparing a stock of sour ale from the materials at hand, brewers seldom employ any other solvent but this. To facilitate solution, it is advisable before steeping the isinglass to cut it into small pieces or shreds. The operation should be performed in a

tolerably large vessel, such as an open-headed hogshead or barrel. The gelatine after a little time will swell up and absorb a large quantity of the acid liquor poured upon it. More of the solvent must then be added, as the mass goes on swelling, until the whole becomes of the consistence of a pulp or thickish jelly. When required for use, a portion of this jelly is taken, diluted in a separate vessel with weak, bright, ale, and rubbed through a hair-sieve. Finings thus prepared should be transparent and free from undissolved particles of isinglass. The density of the solution should not exceed 1·025. The purer the isinglass, the more readily will it dissolve, and the greater the quantity of finings that can be made from the same weight. Dried cod-fish *sounds* are sometimes used in place of the more expensive isinglass, but there is no real economy or advantage in the practice. Indeed there would seem to be some danger of disposing the beer to become rapidly acid and unfit for drinking if any of the digestive fluid of the fish should remain, as is often the case, dried up along with the stomach or sounds.

Other substances, such as alum, white of egg, serum of blood, &c., are now and then employed as substitutes for isinglass finings. None, however, are nearly so effective or so free from objection as the latter.

The quantity of finings usually required is about a pint to the barrel, but the proportion will of course vary with the degree of muddiness of the beer.

All sound, well-brewed, malt liquor which is intended for immediate use and from some cause refuses to clarify of itself within a reasonable time, may be no doubt rendered perfectly bright by the judicious use of isinglass finings, but when the beer is what is called "stubborn,"—that is, when carbonic acid gas continues to be disengaged after cleansing, carrying to the surface small floating patches of yeast, or other turbid matter—the addition of finings will not produce the desired effect, and is likely to prove injurious to the beer. It is always advisable to make an experiment with small quantities, and observe the result before incurring the waste of adding on the large scale so costly a material to beer that will not be improved but rather impaired in quality by the treatment.

Indeed, as a general rule, the use of finings, of however pure a kind, is to be avoided, unless it should be imperative to send out the beer in good condition the moment it has finished cleansing on the stillion. There can be no question that finings more or less impoverish the liquor they are mixed with, and not unfrequently communicate a flat, disagreeable, taste, besides diminishing the sprightliness of the beer as it is drunk.

The exercise of a moderate degree of care and skill in conducting the brewing operations, and, above all, the use of *hard* well-water in mashing, will, except on very rare occasions, enable the brewer to dispense altogether with finings.

Several ingenious explanations have been given of the probable mode of action of finings in clarifying malt liquors. The theory that seems most in accordance with the observed fact is, that the gelatine, or principal component of isinglass, is more soluble in cold, acid, beer or vinegar, than in sound beer, water, or any fluid containing spirit; and therefore that when such finings are added to well-fermented beer, the gelatine becomes separated from the medium which held it in solution, and that in the act of separation it agglutinates or collects together all the lighter, floating, matters which render the beer turbid, and ultimately falls to the bottom of the vessel with them, or rises to the top, leaving the mass of liquor above bright and transparent.

Instead of using finings, it is now a very general practice, after cleansing is finished, to introduce a small quantity of hops into the large round, or each cask on stillion, and to allow them to remain in contact with the liquor until the whole of the suspended yeasty particles are carried down with them as they subside. When fresh, sound, hops are employed there is no doubt of this being a beneficial and efficacious system.

Storing.—Beer, as soon as it is cleansed, and, if necessary, fined as well, is either at once sent out to consumers, or stored in large, close, vessels, to ripen and improve in flavor and transparency. Owing, however, to the preference which at present exists in most parts of the kingdom for mild, freshly-brewed, malt liquors, the large

stocks of old or mature vatted beer, formerly so common, have become of very limited extent, and are to be met with only in a few places. This change of the public taste is, no doubt, a source of satisfaction and increased profit to brewers, as it enables them to turn over their capital more rapidly, and saves the great risk and expense attendant on the long storage of their produce.

As beer cannot be made with advantage in the hotter portions of the year, even where there is an abundant supply of cooling water and the best refrigerators are employed, it is advisable that a stock sufficient to meet the probable demand during the summer months should be brewed in the winter, early spring, or late autumn. A certain amount of storing is therefore unavoidable, if it be desired to have an adequate quantity of good, sound, liquor always on hand, and to escape the losses generally incident to summer brewings. But the vessels used for this temporary storage ought not to be of a greater capacity than to hold when full the produce of three or four moderate brewings each, so that the whole of the contents of a vat may be drawn off with as much despatch as possible after the first removal from it has taken place. Any space left above the surface of the liquor, occupied as it necessarily is with air, favors the development of acidity in the remaining beer, and in that degree tends to injure the quality. The truth of this is well known to every person who has had beer long on draught from a cask in his house. Air, if it does not find its way in through minute chinks or gaps in the wood, must be admitted from above after a time to produce pressure enough to make the liquid run out at the tap; and it is thus that the mischief spoken of is occasioned. Old, matured, beer, of high original strength, in which little further change is likely to arise, may of course be kept on draught, either in vats or casks, for a considerable period without suffering materially from the presence of air.

The more saccharine matter thero is left unattenuated in the beer, the more highly it has been hopped, and the more effectually it has been cleansed, the better does it resist the tendency to acetify, inasmuch as the remaining sugar sustains a slow, secondary fermentation, which adds

gradually to the amount of spirit at first formed in the wort; and the preservative power of the alcohol and of the large proportion of hop-extract, together with the comparative absence of gluten, prevents the finished beer from becoming "hard" or acid to any objectionable extent.

It is chiefly in weak or in highly attenuated malt liquors that rapid souring takes place. In the former, as the worts have contained but little sugar, the beer can contain only a corresponding amount of alcohol, and there is nothing except the property of the hop to counteract the formation of acid; while in the latter case, so small a quantity of unaltered sugar is left in the liquor that the secondary fermentation cannot be maintained, and the original alcohol and the hop-extract prove inadequate to restrain the beer from passing into the acetous condition if even a small amount of gluten be present, and the liquor be kept at ordinary temperatures for any length of time.

It follows accordingly that, in order to preserve the soundness of beer which is not intended for immediate consumption, the attenuation should be restricted in proportion to the smallness of the quantity of malt and hops used. In other words, "keeping ales" must be brewed either at a high original gravity, in which case the worts may be fermented down to the usual cleansing point for "quick draught" ales, or else, if the strength at first be not greater than the ordinary or medium standard, the progress of attenuation must be checked at an early stage so as to fortify the liquor against subsequent injurious changes by retaining in it the requisite body of saccharine extract. The first method is that generally adopted.

Of two vessels of equal capacity but different shape, that which is the deeper in proportion to its area will preserve ale the best, as, in accordance with the laws of physics, the lower portion of the contents of the vessel will be more compressed by the portions above them when the liquor stands in a tall column; and, in consequence, the remaining sugar will be more slowly decomposed as the secondary fermentation advances, and the tendency to acetification will be resisted in the same measure.

For these reasons, deep vats of comparatively small area are to be preferred for the storing of beer.

It is important also that the vessels should be placed where a uniformly low temperature can be ensured; but after filling off into casks, the beer should be gently warmed for a few hours by heating the air of the cellar with open fires, so that the carbonic acid gas may assume the elastic form, and cause the liquor to appear fresh and sprightly just before it is sent out to consumers.

To obviate any ill results from electrical action, the vats should always be raised on a stage above the floor of the cellar or store. The practice which at one time prevailed of sinking the vessels to a considerable depth in the ground must have frequently been productive of serious mischief to the beer from the electric currents traversing the earth.

Another practice of some brewers—that of "flattening" stock ales by exposure to the air for a certain period in large shallow vessels before filling the vats—is also to be condemned, as during such exposure a disposition to acetify must be contracted which no after treatment can wholly neutralize. The mistake is in supposing that the flattening of the beer in this manner will prevent its fretting or engendering further acid in the vat; but it will be found that beer to which free access of air has been permitted until white spots appear on the surface, before being racked into casks, is liable to lose all its sprightliness, and to become rapidly hard and stale as soon as it is placed on draught in the cellars of the consumer or vendor, although when first tapped its flavor and condition may be satisfactory enough. It may be taken as a safe general maxim, that beer which has been properly brewed, and allowed sufficient time to throw down the suspended yeast, and otherwise clarify itself by standing, cannot be too promptly and effectually protected from further contact with the atmosphere. To this end, the vats when filled should be closely covered up, and the contents kept as cool as possible during the whole time of storage.

The important subject of the management of beer in casks will be treated of in a separate chapter.

Miscellaneous Particulars.—*Ordinary gravities of the worts of beer.*—The various qualities or kinds of malt

liquors brewed at the present day, may be classed as follows:—

1° *Small beers, table ale, &c.*, from worts not exceeding 45° gravity.

2° *Medium beers, pale ale, porter, &c.*, from worts averaging about 60° gravity.

3° *Strong beers, old ales, stout, &c.*, from worts of 95° and upwards.

In the strongest English and Scotch ales from eighteen to twenty-seven quarters of malt are required to produce 1,500 gallons of beer. Good porter or ordinary stout takes from sixteen to eighteen quarters for the same quantity.

Under hardly any circumstances can more than from 92 to 94 gallons of finished beer be obtained from every 100 gallons of wort. Draught London porter is usually brewed from worts of about 56° gravity; ordinary stout from worts of 69° to 72°; and the strongest bottled stout and porter for exportation, from worts of 83° to 97° gravity.

Waste of liquor in brewing.— The following may be regarded as about the average losses of liquor during the several operations of brewing:—

LOSS PER QUARTER OF MALT MASHED.

	Gallons.
Retained by goods in mash-tun . .	26
Do. by hops do. . .	7
Evaporated in boiling	23
Do. on coolers	13
Waste in fermentation and cleansing .	6
Total . . .	75

or $\frac{B}{2}\ \frac{F}{0}\ \frac{G}{3}$ from all causes per quarter.

The practical rule to be deduced from this is, that in order to obtain any given quantity of beer from a quarter of malt, or a corresponding weight of sugar, the mash liquors should exceed such quantity by about seventy-five gallons on the whole, so as to allow for the waste or loss incident to the processes of brewing, and so proportionately for a greater or less bulk of materials.

Produce of malt and sugar in brewing.—On the average, four barrels of beer at the original gravity of 20lbs. per

barrel (55° gravity revenue system) are procurable from a quarter of pale malt. A higher or lower gravity will, of course, be accompanied by a smaller or greater proportional quantity of beer. Thus, if the desired gravity be 69°, then the quantity of beer, instead of four barrels, will only be 2 B. 3 F. 4 G. If the gravity is to be 33°, then the quantity will be as much as six barrels. From 200 to 210lbs. ordinary brown sugar is about the average equivalent of a quarter of malt.

Bulk of grains or draff.—When the malt used is of good quality and finely crushed, the bulk of the grains, when the liquor is all drained off, will, in general, fall short of the quantity of malt mashed. Under different conditions the grains may be expected to exceed either slightly, or sometimes by as much as ten or fifteen per cent., the quantity of dry malt. The high temperature of the grains immediately after draining, and the natural compression produced in deep mashes of such closely-adherent particles, are to be regarded as having a considerable effect of an opposite character upon the bulk of the residue in the mash-tun.

The general principles of the art of brewing, irrespective of the strength or particular kind of liquor manufactured, having now been explained at sufficient length, an account remains to be given of the materials, construction, and processes of the brewery in greater detail.

CHAPTER II.

Materials Used in Brewing.

Water.*—It is almost needless to observe that an adequate supply of suitable water is the first necessary of every brewery, but there is no doubt that an undue importance and influence are popularly ascribed to the character of the water used in the manufacture of beer. So long as the water is clear, and free from all traces of decomposing animal and vegetable matter, as evidenced by the absence of any objectionable taste or smell, it will answer the purpose of the brewer and throw no hindrance in the way of producing sound, palatable, beer. It is absurd to suppose, as many do, that the peculiar flavor and other properties of certain ales are chiefly dependent on the composition of the local water.

As previously remarked, however, the *hardness* of the mashing water has a sensible effect in aiding the spontaneous clarification of beer. Indeed, where water of the right degree of hardness, and having the proper saline ingredients in solution, is regularly employed, the use of finings is rarely required, and the beer is saved much probable injury in consequence.

Although pure, soft, water from any source will enable a brewer to obtain a good extract and prepare marketable beer without difficulty or disadvantage, except as regards the use of finings, it is certain that water which contains a small amount of saline matter, especially sulphate and carbonate of lime, is the best adapted for brewing purposes. Such water produces quite as great an extract as the softer kinds, and has, in addition, the valuable property of causing the beer to clarify itself thoroughly in a short time after being cleansed.

*** "Analysis of Brewing Water," conducted by W. R. Loftus, at his Laboratory, 146, Oxford-street. (See page 163.)

The reason of this action of hard water in brewing has not been satisfactorily accounted for either by scientific or practical men, but long and varied experience in different localities makes the fact indisputable.*

Gypsum, or sulphate of lime, is the salt which exercises the most useful effect. Carbonate of lime is also beneficial in a secondary degree. The total amount of saline or mineral matter should not, if possible, be less than 60 grains in the gallon; and, as a readily-applied test of the water possessing the requisite hardness for brewing, it should curdle soap into thick, hard, flakes. Surface-water is never fit for the use of brewers, as it invariably contains decaying organic matter. Rain-water, collected directly from the sky, may be resorted to in an exigency without any great disadvantage, but river-water is almost sure to produce ill results.

If on occasion none but impure water can be obtained, a partial remedy may be applied by boiling briskly for some time prior to making the first mash and then cooling to the proper temperature, as the boiling causes the carbonate of lime which is usually present to precipitate, and this carries with it the greater part of any organic matter dissolved in the water. The green color of the crust formed on the sides of the copper will show the impurity of the water.

As a general rule, spring or well water obtained from a considerable depth below the surface, and freshly pumped up, will be found the best in all respects for brewing purposes. But even in this case it is advisable that the water, however bright and sweet it may appear, should be carefully tested now and then to detect latent impurities which escape the eye and nose and may yet exist to an extent most prejudicial to the quality of the beer, and also to determine whether the necessary degree of hardness is present. If not, impregnation with sulphate of lime may prove an efficient corrective.

Mineral waters of any kind are, of course, quite inadmissible, particularly those which have the least trace of iron.

MALT.—Malting, as before remarked, is a process by which germination to a limited extent is artificially

* See page 61 for an account of the most probable explanation of this fact.

induced in barley or other grain with the object of providing an eligible saccharine material for the use of brewers, distillers, &c. During this process a small quantity of a peculiar substance termed *diastase* is formed, which changes a portion of the starch* of the grain into dextrine, or gum, and thence into sugar, and has also the property of saccharifying the whole of the remaining starch when the malt is subsequently infused in hot water, as in the mashing operations of the brewer. Wheat, Rye, Oats, Beans, Peas, and Maize or Indian Corn, are each occasionally made into malt, but barley is found to be the most economical, and the best suited to the purposes of the brewer. Both wheat and rye being destitute of husk, do not afford that protection to the germ, or vital portion of the grain, which is found in barley and oats; hence the germ is easily mutilated, and the grain, in consequence, soon becomes mouldy and undergoes decomposition. Oats, on account of their thick husk, small kernel, and slowness in germinating, are unprofitable, whilst the malt made from maize, beans, or peas, has not hitherto been used with any great success in the brewing of beer.

The barley chiefly malted in England and the southern parts of Scotland and Ireland, is the two-rowed variety *(Hordeum distichon)*. In the northern parts of Scotland and Ireland, the six-rowed barley *(Hordeum hexastichon)*, otherwise called *bere* or *bigg*, is also extensively used for malting.

In the manufacture of malt four principal operations are necessary, namely, steeping, couching, flooring, and kiln-drying.

Steeping.—The barley, after having been screened and cleansed, to free it both from small and useless corns, and from the seeds of wild plants and other accidental impurities, is placed in a vessel called the "Cistern," and is covered with water and kept immersed, under ordinary circumstances, for a period of from 40 to 50 hours. While in steep the grain softens and increases in bulk over a fifth, by the absorption of water, and nearly one half in weight.

* Recent experiments show that it is chiefly the *cellulose*, or woody tissue of the grain, which undergoes transformation into sugar, and that most of the starch, or fecula, remains unaltered.

Carbonic acid gas is also formed, which dissolves in the steep water along with a portion of coloring matter from the husk. Sometimes, especially in hot weather, a slight degree of fermentation arises from the vegetable matter in the steep-water acting on decayed grains, and hence it becomes occasionally necessary or advisable to change the water during the period of steeping.

The barley is sometimes allowed to remain under water for a period varying from 40 hours to 80 hours, according to the season, temperature, and condition of the grain. If a corn, taken from any part of the heap and held lengthwise between the first finger and thumb, readily breaks down into a pulpy state when squeezed, the steeping is judged to be complete. The water is then drained off, and the grain removed into an adjacent rectangular vessel called the "couch-frame," where it is kept in a mass of considerable depth for at least twenty hours, in order that heat may be developed, and germination induced.

Couching and Flooring.—Very little apparent change takes place in the grain for from 30 to 40 hours after removal from cistern. The temperature of the mass then begins to rise, and the rootlet, or, as maltsters term it at this stage the "chick," or "chit," shows itself as a small, white, bud, emerging from under the husk at the base of each corn, that is, the end by which it was attached to the stem.

In about two days afterwards, the grain becomes moist on the surface, or "sweats," and emits an agreeable odor, compared by some persons to that of apples, and the white bud developes into several fibres, or rootlets, which spread, and shoot downwards. At about the same time, the acrospire, plumule, or that which would be the future stem of the plant, begins to grow; it takes its rise at the same end of the grain as the rootlets, but pursues its way under the husk, along the back of the grain, in an opposite direction to that of the roots, and may be readily perceived on removing part of the husk.

To lower the temperature, and thereby moderate the germination or growing process, the grain is now spread rather thinly on the floor and frequently turned or stirred. By this means the corn is kept at an average temperature

of about 60° F.; vegetation proceeds slowly and regularly, and the starchy matter of the grain becomes white, soft, and friable, and sweet-tasted so far as the plumule or aerospire has advanced. In ten or twelve days after the grain has been emptied from cistern, the frequent turnings and exposure to the air, together with the growth of the rootlets and aerospire, have dissipated the greater portion of the moisture absorbed in the steeping, and the rootlets wither. It is then laid a little thicker on the floor to generate heat, liberate more moisture, and render it mellow, and by this time the acrospire ought to have grown to two-thirds or three-fourths the length of the corn. The grain, now properly malted, is dried on a kiln to arrest germination, which, if suffered to proceed beyond this point, would exhaust the seeds of their soluble contents, the gum and sugar that had been previously formed rapidly disappearing to supply nourishment to the young plant. Drying has also the effect of enabling the malt to be kept in store without further change.

Many maltsters work their floors on a plan somewhat different from the preceding. The floors are kept thick, and germination is forced, abundance of rootlets being formed. The heat generated in this process dissipates a part of the moisture absorbed by the grain while in steep, long before the plumule has grown to a sufficient length. Hence, it is requisite to sprinkle the corn with water, in order to stimulate germination. In a few of the malting districts, however, sprinkling is not resorted to as a practice, it being thought unnecessary and injurious. But when a maltster works for "out-come" or "out-cast," as it is termed, that is, with a view chiefly to a large increase of produce over the quantity of barley steeped, rather than with the desire to obtain malt of fine quality that will tend to the profit of the brewer, it certainly proves of advantage to water the corn on the floor, as that treatment has the effect of increasing the bulk of the finished malt. In other words, sprinkled grain "measures well" off the kiln.

Kiln-drying.— This operation is effected in a heated chamber termed a kiln, the floor of which is formed of perforated tiles or metal plates, wire-gauze, or hair-cloth.

Heated air from a fire placed underneath, passing through the malt, stops the further progress of vegetation, and rapidly carries off the moisture, which escapes through the windows or an opening in the roof. Other special modes of drying are occasionally resorted to, but some form of kiln is in general use.

The process of kiln-drying varies according to the purpose for which the malt is required. There are three well-marked varieties of kiln-dried malt, namely *pale, amber,* and *brown,* the difference between these depending solely on the degree of heat to which each has been subjected, and the manner in which the heat has been applied. Pale malt is usually made from the best barley, and occupies from two to three days in the drying, the temperature being slowly raised from about 90° F. to 120° F., and the grain frequently turned. Amber malt is treated in a similar manner, until it is almost dry, when, to give it a slight scorching, the temperature is raised to 160° F. For brown or porter malt, the grain is placed to the depth of about half-an-inch on the floor of the kiln, which, in this case, usually consists of perforated iron plates or wire net-work, while a strong, blazing, fire, produced by the ignition of faggots of wood, is applied below. During this process, the temperature rapidly rises to 180° F., or higher; a portion of the starch and sugar of the malt becomes carbonized, while, as some allege, the pyroligneous acid and other products evolved from the burning wood, impart to the malt that peculiar flavor so much esteemed by the porter drinker. When the drying is completed, the workmen usually tread the malt to detach the rootlets from the grains; the rootlets are now termed "commings," and these are effectually separated from the malt by passing it over an inclined screen, which permits the commings to fall through, while the grains roll down.

In the process of malting, barley loses from eight to twelve per cent. in weight, and increases from three to ten per cent. in bulk.

The grains of malt are generally free from wrinkles, although, sometimes, they have a slightly shrivelled appearance. The husk has a lighter color than that of barley, and remains open at the end from which the rootlets have protruded.

A bushel of good barley weighs from 49lbs. to 56lbs.; a bushel of well-made malt weighs from 38lbs. to 43lbs.

Malt differs considerably in appearance from barley; the bright, yellowish, hue, and shining aspect of the husk have disappeared, and instead of the tightly-closed end which characterizes an unmalted barleycorn, an opening through which the rootlets have passed may now be observed at the base of each grain.

As regards the internal changes, it is found that the toughness natural to barley is no longer present, and that the body of the grain has become mealy or friable, while, underneath the husk, the acrospire is seen to have grown nearly three-fourths of the length of the grain.

It is, however, when ground or crushed, and mixed with water, and kept for one or two hours at a temperature ranging from 150° F. to 180° F., that the alteration produced in barley by the process of malting is most strikingly exemplified. Under such circumstances, the white and turbid solution of the remaining starch is observed to be converted into a sweet, transparent, liquid—the starch, in fact, being almost wholly transformed into sugar.

Tests of quality.—Malt should be perfectly crisp and tender, free from the least mould or mustiness of smell or taste, the husk of the grain thin, and each corn, or "pickle," plump, clean, and unshrivelled, with no hard or ricey ends. The grains should break easily when held between the finger and thumb and pressed with the nail, and disclose a full, floury, kernel which if drawn across a board should leave a chalky trace. In properly malted barley the acrospire, as above stated, may be seen to extend up the back, beneath the skin, to three-fourths or even seven-eighths of the length of the grain. If *uniformly* as far as seven-eighths, so much the better, but the least protrusion beyond the top of the seed indicates an exhausted and worthless condition within. The grains of each parcel of malt should all be nearly equal in size, and have attained the same amount of growth. Irregularity in the degree of vegetation is a great objection. A good judge will look carefully amongst the sample for dead corns, "idlers" or "sleepers" as they are termed, and count the number: in ordinary seasons there should not be at the

outside more than five per cent. either of wholly or partly ungerminated grain. As malt is specifically lighter than water, a common and convenient test of quality, is to take, say, 100 pickles, indiscriminately from the bulk, throw them into a glass of cold water, and stir them up. Thoroughly malted corns will float lengthwise on the surface; those only half or partly malted will dip from the surface at various angles, with one end pointing downwards, the obliquity of the angle showing the extent of the growth; the wholly unmalted corns will sink to the bottom. By noting the number of grains which behave in each of these ways respectively, an accurate opinion may be formed as to the character of the malt. It is necessary that the experiment should be made quickly, as after a time even the malted corns will become saturated and sink to the bottom. The fact that the grains have undergone any degree of germination may be easily determined by inspection of the base or rootlet-end of each corn. If roots have protruded, this end remains open and presents a marked difference of appearance to the tightly closed end of an unmalted barleycorn. The husk of raw grain also has numerous wrinkles from which malt is comparatively free.

"Steeliness" in malt, that is, a hard, flinty, condition of the kernel, is that which causes it to yield the least produce in brewing. This quality shows itself both by the water-test and by trying a few grains lightly with the teeth. Mouldiness is however the worst fault of all. The best pale malt, made from fine, heavy, barleys, such as the improved culture of the present day supplies in large quantity, weighs from 40 to 43lbs. per bushel. If the grain be all well malted, the greater the weight of the malt the larger will be the amount of extract obtained from it in the mash-tun, the true criterion being of course the gravity of the worts in each case. The proportion of husk is smaller in heavy than in light malt, and according to the amount of husk will be the amount of extract yielded in the mash-tun.

Malt weighing 40lbs. per bushel should give at least 80lbs. of *gravity* per quarter; and it may be estimated that each pound of increase in the weight above 40 (supposing the quality to be the same) represents 8s. additional value per quarter to the brewer.

Amber malt weighs on the average from 38 to 40lbs per bushel.

When the paleness of malt has been fraudulently produced by the fumes of burning sulphur used at the time of kiln-drying, there is a probability that some of the sulphurous acid engendered will cling to the grains, and interfere with the progress of fermentation in the tun. Malt so prepared should therefore be avoided by brewers.

As a general rule it is not advisable to purchase malt that has been made between the months of May and October, as during the summer germinating grain is very prone to become mouldy before it is fit for the kiln.

All malt received into the brewery should be examined to see that it is free from adhering rootlets and dust, and that which is intended to be used in the manufacture of fine ales should be selected of a uniform color or degree of paleness.

In the storing of malt *wooden* bins should be employed in preference to those built of stone or brick-work: the latter materials attract and retain moisture, by contact with which the malt becomes, as it is termed, *slack*, and in extreme cases mouldy and infected with the weevil.

Malt, which is merely slack, may be recovered and used without disadvantage by re-drying on a kiln. Some writers affect to recognise no fewer than six different shades of malt from pale or white up to deep brown or black. But it is very rarely now-a-days that any but the the three well-known and decided varieties of pale, amber, and black are to be met with in the market or seen in the brewery.

Roasted Malt.—Roasted malt, patent malt, or black malt, as it is variously called, is used by brewers for the purpose of giving to porter its rich, dark brown color and peculiar flavor, and in some districts, as in Lancashire, for the purpose also of deepening the color of ale and beer worts. The preparation of this substance is carried on as a special business, and is a trade quite distinct from that of malting. Ordinary malt, as has already been stated, may be rendered suitable for porter brewing by raising the heat of the kilns at the end of the drying process, or by subjecting the malt to the action of

a wood-fire, but as a great portion of the fermentable matter is destroyed by this method, recourse is generally had to the use of roasted malt, a small quantity of which imparts to the worts of pale malt all the color and flavor that can be desired.

The process of roasting malt is very similar to that of roasting coffee. The malt is placed in a metal cylinder, which is made to revolve over a charcoal or coke fire; by this means the malt is slowly roasted at a temperature varying from 360° to 400° F., until it assumes a dark chocolate colour. *Caramel*, or burnt sugar, a blackish brown substance, exceedingly soluble in water, and of a bitter, empyreumatic, flavor is thus produced, while at the same time part of the grain is unavoidably carbonized, or reduced to charcoal.*

Caramel, although formed from sugar, will not ferment or afford alcohol, and in this respect is of no use to the brewer. Its principal value consists in its coloring power, whilst at the same time it adds considerable density to the worts. Brewers occasionally avail themselves of caramel for colouring their beer, but in most cases roasted malt is used by preference in the manufacture of the better class of malt liquors. Still the use of caramel for ordinary beers requiring to have a deep color is on the increase; and now that the revenue laws no longer forbid the brewer to purchase this substance ready made there is little doubt that with an improved quality there will be a steadily greater demand for it on the part of brewers. W. R. Loftus is in a position to supply caramel of the finest kinds at the lowest market price, and will be happy to execute orders to any extent.

Malt loses in weight, during the process of roasting, about 10 lbs. per bushel, and increases about 6 per cent. in bulk, while barley treated similarly treated loses about 12lbs. per bushel, and increases in bulk from about 14 to 22 per cent., and may, by peculiar management

* If the heat exceed 420°, the malt becomes almost wholly decomposed, leaving nothing but a mass of porous charcoal. Caramel, when pure, is nearly tasteless. The substance met with in commerce under that name is prepared from cane-sugar, and generally exists as a thick, syrupy, dark brown liquid, of bitter taste, and intense coloring power. It is largely used by rectifiers to impart a brown tint to compounded spirits.

in roasting, be increased even to upwards of 50 per cent. This difference depends chiefly on the degree of rapidity of roasting, and as malt of all kinds is sold generally by measure there is a strong inducement for the roaster to practise the substitution of raw barley for malt, although roasted barley is not nearly so well adapted as roasted malt for the coloring of beer. It is of considerable importance to the porter brewer to be able to distinguish the genuine from the spurious article, and this he may readily do by examining a sample of the corns, in the manner directed on page 81 to see whether they have germinated, and by noticing that the grains of roasted barley are shorter, thicker, and less liable to fall in pieces than those of roasted malt, and also that the wrinkled appearance of the husk is not altered as in the case of malt.*

In the brewing of porter or stout, from 3 to 5 bushels of black malt are usually found sufficient to give the requisite color and flavor to the worts obtained from every 100 bushels of pale malt. The use of too much roasted malt imparts an objectionable taste like that of licquorice. It is necessary to bruise roasted malt much more finely and completely than pale malt.

Sugar.—Common, raw, West India sugar, as imported in bags or hogsheads, is that generally made use of in brewing. Highly refined sugar would be too expensive for the purpose, its greater saccharine richness not making up for the difference of price, although of course superior delicacy of flavor is obtained in proportion to the purity of the material.

Within the last few years, solid, or nearly solid, saccharum prepared in this country by a patent process from the refuse of the sugar refineries has been introduced with some success into breweries. This saccharum is not so sweet as the cane sugar it is derived from, but it is much more free from nitrogenous matter, and is said to produce beer of unexceptionable quality when employed as a partial substitute for malt. When used as the *sole* material in brewing the results have not hitherto been satisfactory,

* For a minute account of the various kinds of malt and a compendious treatise on the Art of Malting generally, see the "Maltster;" to be had of the publisher of this work, post-free, 3s. 6d.

and the same may be affirmed of ordinary foreign sugars. One of the chief advantages of brewing from sugar is the simplicity of the process of preparing the wort, mere solution in the proper quantity of water being all that is requisite. It is, however, in porter brewing that sugar finds its most extensive application. The coarseness of the flavor and the color of the solution are of little or no moment in this beverage; indeed the bottoms of the casks of moist sugar which stand in grocers' shops, saturated with the molasses or the drainings of the mass above, and technically called "Foots," are commonly sold for the use of porter brewers, but it is difficult, except perhaps with the patent saccharum, to make good-keeping ales from sugar: when the liquor is intended to be consumed quickly, as in summer, sugar often proves an efficient substitute for a portion of malt.

As previously stated, two cwt. of the lowest quality moist sugar may be taken as the average equivalent of a quarter of pale malt. If sugar of a purer and finer kind be used, as for instance medium Jamaica brown, then from 200 to 210 lbs. will be sufficient to yield worts of about the same quantity and purity as a quarter of malt.

It is not advisable, as a general rule, to replace the malt by this material to the extent of more than one-third, or at the outside one half. In brewing light bitter ales, if sugar be used at all, it should be either the patent saccharum or the finest imported, and the proportion should not exceed from one-sixth to one-fourth of the estimated quantity of extract of malt in the wort. Further information on this subject will be given in the chapter entitled "THE USE OF SUGAR IN BREWING."

HOPS.—Hops consist of the female floral leaves, strobiles, or catkins, of a perennial climbing plant, the *humulus lupulus,* extensively grown in certain parts, chiefly the southern counties, of England, and also in Bavaria and other Continental States. The fruit of the hop plant is a small, rounded, seed enclosed in a scaly calyx or cup which contains at its base a granular, yellow, substance having to the eye the appearance of fine dust. This powder or secretion forms the most valuable portion of the hop, as upon it the narcotic and astringent properties

depend. It amounts to about one-eighth of the weight of the hops.

The catkins ripen in September, and are then picked from the "bines," and gently dried on kilns in what are termed "Oast houses:" the leaves are laid in heaps on the floor until they become slightly heated, when they are immediately bagged. Successive layers are put into each bag or "pocket" and well trampled down. To exclude air effectually, the contents of the bags are forced together by means of powerful screw or hydraulic presses; by this treatment the valuable yellow powder and essential oil are preserved for years. The best hops have a bright, golden, color and a strong, agreeable, aroma; when rubbed between the hands the hops should leave a fine powder without any broken parts of the plant, and on being digested in hot spirits of wine and the liquid evaporated should yield from 9 to 12 per cent. of soluble yellow residue. This is the best criterion of quality, and should always be applied before purchasing. Foreign hops do not as a rule possess the rich flavor of those grown in England, but answer very well for most purposes in brewing when used to the extent only of about a-third or a-fifth of the latter. Of late years, Bavarian and occasionally American hops are getting into general use in this country. It has been found, that in ordinary pale ale or bitter beer one-third of common hops may be employed to give the flavor and bitter required, while another and finer kind is resorted to for the superior odor it imparts. The powder or pollen which falls through the meshes of the hair-cloth or wirework of the kiln-floor in the course of the drying, is of considerable value to brewers. It is known in the trade as "hop dust," and, when collected free from extraneous matter, is nearly equal in efficacy to the hop itself. In porter brewing especially, a certain amount of this dust may be used with great advantage.

Fumigation with burning sulphur is frequently practised, as in the case of malt, to give hops a pale color; but the effect of the lingering sulphurous acid is detrimental to the success of fermentation, and hops which have been bleached in this manner, however slightly, should be avoided if possible by the brewer.

The counties of Kent, Sussex, and Hants are the principal sites of the cultivation of the hop-plant in England; a mild, delicate, variety is extensively grown in Worcestershire. The Kentish hops have the greatest strength and flavor; the color of these is a rich, golden, yellow with a greenish shade; when rubbed in the hands, they leave yellow traces, exhale a strong, agreeable odor, and are in a marked degree oily and clammy to the touch. "Farnhams" or "Goldings" are the finest flavored of all the Kentish hops, but they are not so strong as the best growth of other parts of the county. The Sussex hops possess much of the general characteristics of the Kentish produce, and are esteemed of nearly equal value. "Worcesters," as already stated, are milder than either Sussex or Kents; they have a delicate flavor, and are chiefly used in pale ale and bitter-beer brewing. "Kents" are best for old ales and stout; the crop, however, is uncertain, the plant being one of the most tender cultivated; these hops are the heaviest grown, possess the greatest amount of "condition,"* and have the smallest flower or leaf. The "Canterbury grape" is a very useful and abundant hop. The kind produced in the district of North Clay, in Nottinghamshire, is also in high repute, as having great strength and condition, although coarse in flavor until mellowed by keeping.

A very pale or green color shows that the hops have been gathered too young, while a deep brown shade indicates either that they have been over-dried, by which most of the aroma must have been lost, or that they have been allowed to ripen too long on the poles, and thus deprived both of aroma and bitterness.

Fresh hops are much more valuable than those which have been kept for any considerable time. A fourth more is, at least, needed when hops a twelvemonth old are used. At one year old, hops are called "yearlings." At the end of two years they retain little else than the bitter, and are then termed "old hops." After the lapse of three years they receive the name of "old olds."

The best hops are packed in bags or "pockets" made of

* See page 35 for an explanation of this term.

strong canvas, which when filled weigh from 168 to 196lbs each. The darker and more strongly flavored are put into coarser sacks, called "hop bags"; these usually weigh about 3 cwt. Hops of this kind are chiefly consumed in porter-brewing.

Nearly the whole of the hop trade for the kingdom, that is, the business of buying and selling on the large scale, is carried on in the Borough of Southwark, London. Owing to the precarious nature of the crop, the amount of annual production of marketable hops is very uncertain, and when an Excise Duty was chargeable on the article, speculation and betting prevailed to an extraordinary degree as to the total of the tax that would be derived from each season's growth.

The importation of foreign hops is rapidly increasing. On the 1st of January, 1862, shortly before the duty was repealed, there were 11,991,264 lbs. of foreign hops in bond. In England the number of acres under cultivation for hops has varied from 38,281 to 58,000, and the price per cwt. from £27 10s. in 1817 to as low as £2 15s. in good years.

In choosing hops, the heaviest pockets should always be preferred, as the greater part of the weight is given by the farina or pollen, and it is the abundance of this constituent which mainly determines the value of the hops. As previously observed, the hops should feel clammy when squeezed in the hand, and give out a strong, characteristic, odor; the color should be uniform; there should be no greenish particles in the flowers, and the mass of leaves should be full of hard seeds and pollen or "condition."

Mould may be considered as present in the sample if the stalk of the flower is partly bare of leaf. Crust, proceeding from damp or bad storage, should also be carefully looked for, as it impairs the value more than age.

It is hardly necessary to say, that brown or dark-colored hops should be used for brown or black beer, and pale hops for pale beers. Hops of a fine straw color, as having been riper when picked and better cured or dried on kiln, are generally esteemed the best for pale ale or bitter beer. Fine Sussex or Worcester are well adapted for beer intended for immediate consumption.

Yeast.—The nature and properties of this substance have been sufficiently described in the preceding chapter. A few practical observations on the best mode of storing and using it are now to be given.

It is advisable to allow the yeast, as it works over from the casks along with a portion of wort during the cleansing process, to remain undisturbed in the stillions or troughs until it is required for exciting fermentation in the gyle-tun, as when removed into large tubs or other receptacles, and considerable quantities of it thus brought together, it is prone to set up an intestinal action or "fret," by which it loses strength and gradually becomes unfit for carrying on a quick and vigorous fermentation when added to the body of worts. Before putting the yeast into the gyle-tun, it should be drained as far as possible from the accompanying wort, and allowed to become thick and nearly solid, in order that the proper quantities may be weighed or measured with exactness. In remote country places where it is difficult to procure supplies of yeast as it is wanted for occasional brewing, it is a good plan to keep the surplus over from previous brewings and to store it in the coolest part of the premises, pouring cold water over it from time to time—the colder the better. Yeast is generally in its best condition the second or third day after cleansing, but in most cases, it will be found sufficiently solid in 24 hours, complete separation from the wort in the troughs having first been effected.

As it is imperative that yeast should be added as soon as the worts begin to run from the coolers into the gyle-tun, no brewer should undertake a mashing until he has provided a proper supply of this material.

After weighing out the right proportion of yeast, a little wort—say about a fourth part—at the temperature of 80° or 85° should be mixed with it, and the whole allowed to enter into brisk fermentation before the tuns are pitched. A quicker and more certain action will be thus induced.

The quantity of yeast necessary to be used is regulated by its freshness, the strength of the wort, and the temperature or "pitching heat." A dense or heavy wort requires more yeast than a light or weak one. A larger proportion

must be added also if the yeast be stale, and also when from any cause the pitching heat is low.

As a good general rule, based upon the practice of successful brewers, it may be laid down, that when the worts are set at a temperature of from 58° to 62° F., and the yeast is fresh and solid, about 1 lb. per barrel will be sufficient for worts of the medium strength of 25lbs. gravity. For every five degrees of reduction of temperature, one-eighth lb. more yeast, and for every five degrees of increased heat, one-eighth of a lb. less should be used. From these data, the proportional quantities for worts of other gravities may be correctly inferred by calculation; thus, for a wort of, suppose, 35 lbs. gravity, we have,

	Grav.		Grav.		Lb. yeast.		
As	69°	:	97°	::	1	:	1·2

Answer, 1·2 or 1lb. 3 oz.

Again, if the pitching heat be 70° F., as 70° is 10° higher than 60°, the mean of 58° and 62°, the wort will take 2 one-eighths, or a quarter of a lb., less yeast than it would require at the assumed standard temperature, that is, three-quarters of a lb. per barrel.

It is of the greatest importance in ensuring a regular and satisfactory fermentation that the proper quantity of yeast should be accurately *weighed out* (not measured) according to some approved standard such as the above, with a proportional allowance for any material difference of gravity and temperature. Too much yeast causes rapid and violent working which cannot be readily controlled, and induces a nauseous, bitter, flavour in the beer that hardly admits of remedy. An insufficient addition of yeast occasions slow and incomplete attenuation and exposes the beer to the risk of becoming sour and remaining almost incurably foul.

Many brewers are in the practice of employing as much as 2 lbs. of yeast per barrel for worts of medium gravities at the ordinary pitching heats; but it is certain, that under these circumstances, any excess above 1 to $1\frac{1}{4}$ lbs is unnecessary and hurtful.

FININGS.—The following receipt for the preparation and mode of using isinglass finings is given in Black's

Treatise on Brewing:—Let any quantity of isinglass which may be thought necessary according to the scale of the brewing operations be taken, cut into shreds or parings, and placed in an open-headed cask. Let the cuttings then be covered with vinegar—which is the best solvent, and the stronger the better—or with very acid old beer, to the depth of five or six inches. When, after a short time, the isinglass has swelled up so as to have absorbed all the liquid on the top, more of the solvent must be added, again covering the mass to the depth of five or six inches; the mixture should then be briskly stirred with a stout pole, and the same process repeated as the isinglass goes on swelling, until the whole becomes of the consistence of pulp or thick jelly. Whatever quantity may be wanted for use should be taken out and put into another open vessel, and there mixed with weak, bright, beer, until brought to a proper consistency for use. This liquid should be rubbed gently through a fine hair sieve with a hard brush, and the portions which will not pass through returned to the first vessel, there to undergo further digestion. No more vinegar or old beer should now be used, but the isinglass in the original cask, as it keeps swelling and thickening, must be thinned down with weak beer, as before, until it is sufficiently liquid to be rubbed through the sieve. The quantities required for use on each occasion are best prepared in this manner.

Well-made finings are transparent and free from undissolved particles of isinglass. The purer the isinglass the greater the quantity of finings that can be made from the same weight, and the less the time taken in dissolving. The application of heat in any degree hardens the isinglass and retards rather than hastens solution; it is improper to use water either hot or cold as a solvent, as finings thus made coagulate when put into the beer and at once go to the top or the bottom of the liquid without producing any clarifying effect.

For brewings on the small scale, a useful receipt is as follows—

Digest 1 lb. of common isinglass in half a gallon of stale beer. From one-half to three-quarters of a pint of the resulting solution will suffice to fine a hogshead of ale.

Before using the finings mix the required quantity with a quart or so of the ale, stirring the whole briskly for several minutes. As soon as this mixture is added to the bulk of the ale, rummage well so as to diffuse the finings through the liquid. The preparation of finings is now made a separate branch of trade, it being found by brewers generally that it is on the whole cheaper and better to purchase from a manufacturer who brings special skill to bear upon the production of an article of uniform efficiency.

The isinglass used for brewers' finings is chiefly that imported from Russia and the Brazilian States. It costs on the average from 3s. to 5s. a pound.

CHAPTER III.

SITE AND CONSTRUCTION OF BREWERY: VESSELS AND UTENSILS USED IN BREWING.*

SITE OF BREWERY.—In erecting a new brewery of any extent, an open, unconfined, situation should if possible be chosen so as to ensure a free current of air round the coolers and favor the rapid escape of steam from the mash-house. Hot, fresh, wort in the process of cooling is very prone to contract ill odours from the atmosphere, if any be present, and to retain the taint even after passing into the condition of finished beer. On this account it is advisable not only to build the brewery in an airy locality but also to avoid the neighbourhood of open drains or stagnant pools of water.

Another important consideration in the selection of a site is, of course, the question of water-supply. For ordinary cleansing purposes, washing out casks and vessels &c., river or rain water, or the water furnished by companies generally, will answer well enough. But, as has been more than once remarked in former chapters of this work, hard, well water, free from all impurities, may be said to be essential to successful brewing. Hence, the value of a spring on the premises or within a short distance, yielding an abundance of water of the kind best adapted for mashing. The cost of sinking a well to obtain such water, or in default of it, *hard* water of some description, considerable as it may be, is soon amply repaid in the improved character and condition of the beer. When circumstances constrain the brewer to employ soft water, it will be of great advantage to place a little broken limestone or marl in the reservoir, so that the mash liquor may become impregnated to some extent with lime salts before it is used.

* See page 8, Scamell's Advertisement.

CONSTRUCTION OF BREWERY.—If space will permit, the coppers and mash-tuns should be so placed as not to allow the steam or heat to affect in the least degree the coolers, fermenting tuns, or indeed any of the other parts of the brewery; that is to say, there ought to be as effectual separation as practicable between the mashing and boiling departments and the cooling, fermenting, and storing departments. The presence of a body of steam greatly retards the cooling of the worts, and exercises also an injurious effect on fermentation and the keeping qualities of the beer.

One of the chief aims in the planning of a brewhouse should be to economize labor to the utmost by a judicious arrangement of the utensils, vessels, and machinery; and as the avoidance of delay in the mashing and cooling processes is of the first importance, every person erecting a new brewery should make the building of sufficient height to allow of the liquor-copper (that in which water only is boiled), commanding the mash-tun, the mash-tun commanding the underback and wort copper, and the wort copper running into the hop-back. Very little pumping would then be necessary, and the less pumping there is the better, as the action of pumps is frequently slow and uncertain, and it is difficult to keep them clean and sweet When the mash-tun stands on a higher level than the wort copper, an underback may be advantageously dispensed with altogether, and the wort discharged direct into the copper. But when this arrangement is adopted, as the produce of the first mashing may be still in the copper at the time the succeeding worts are ready to be drawn off, it will be requisite to provide either a second wort copper, or else a "wooden heating back" through which steam may be passed, and to run the worts from the mash-tun into such copper or back, there to be kept at a tolerably high temperature until the principal wort copper is ready to receive it for boiling with hops. The injury so liable to occur by allowing the worts, as is the common practice, to remain a considerable time in the underback, losing heat and forming acid, would thus be wholly prevented.

Another recommendation of providing a second wort

copper or the back in question is, that it affords a convenient receptacle for the raw or return wort which is usually held over from one brewing to the next, and if the vessel be placed below the mash-tun a wort pump will be unnecessary, whereby much time and labor will be saved.

The *Hop back* should be large enough to contain the entire charge from the copper, and its position should enable it to command the coolers or refrigerator, although it is seldom that breweries are erected of a sufficient height to permit this arrangement to be carried out.

It is also very desirable that the coolers and refrigerator should command the fermenting tuns, and these again the cleansing vessels. No pumping whatever need then be resorted to except that of the mashing water when conveyed into a tank at the top of the building. The "liquor tank" is best made of cast iron; its capacity should be at the rate of at least 10 barrels for every quarter of malt the house is capable of mashing. A full supply of liquor should always be pumped up into the tank some hours before the commencement of each brewing, but it is doubtful whether the long exposure to the air which many writers recommend is unattended with bad effects.

In most breweries the system prevails of having only two coppers, both at the same elevation; one a liquor-copper which commands the mash tun, an underback beneath the mash-tun, and the second a wort copper, into which, from its position, the contents of the underback must be conveyed by pumping. The disadvantage of this arrangement has already been pointed out, as also the inconvenience and injury that arise from the absence of an additional copper or a heating back.

Where there is only one copper, brewing cannot be conducted on anything like a large scale, the proper order of the operations cannot be maintained, no despatch can be practised, and the results are seldom uniform or satisfactory.

Heating by steam instead of by open fires is now very generally practised, and for most purposes with economy of fuel and advantage to the flavor of the worts.

The cellarage should always be as ample and spacious as circumstances will permit, and at such a depth below the

ground as will ensure the maintenance of a constant temperature varying between 44° and 50° F. The better to attain this object, the vaults should be arched with bricks and the walls made thick and substantial.

Vat Rooms require to be lofty, cool, and closely covered in at top. The vessels should rest on strong supports at such a height from the floor as will allow of the largest cask used in the business being easily placed under the taps.

Malt and Hop Chambers and Bins should be on the second storey, in a dry situation, and with firm ceilings and boarded floors. The sides of the bins should be of dry wood, and if there is the least internal damp the walls of the store rooms should be boarded also.

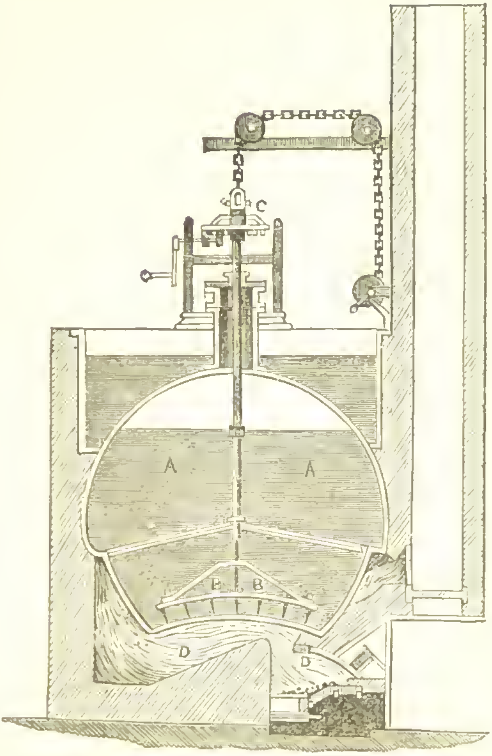
To guard against ill effects from electrical action, there should be as little metal piping as possible, and only one kind of metal employed throughout.

Lime, as a cheap and efficient purifier, should be frequently used in the cleansing of the various parts of the brewery.

Vessels and Utensils.— *Coppers.* —Thin, well-hammered sheet copper should be used in the construction of these costly utensils. Thickness of metal beyond a certain point does not confer additional strength, while it seriously enhances the expense, and a moderately thin copper wears longer and heats more rapidly. The metal need not be of any greater stoutness than will enable it to bear without injury the weight of a man when standing on the bottom to clean it out.

As to size—if there be but one copper in the brewery it cannot be too large, as it will have so much work to perform. In this case it should have the capacity of, at least, five barrels for every quarter of malt that can be mashed. It is an advantage of a large copper that it often makes it possible to boil the several worts at ouce, thus economizing time and fuel.

All extensive breweries, as has been already remarked, should possess at least, coppers of nearly equal size, one exclusively for the heating of liqour or water, and the two others for the boiling of worts. The coppers should not be of less capacity than from three to four barrels for every quarter of malt brewed.



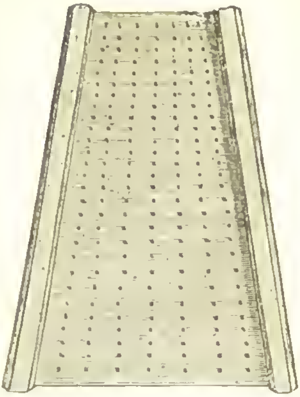
A sectional view of the best form of close wort copper, with its appendages, and setting in the masonry, is shown in the opposite sketch.

It will be seen that the copper is concave or raised inwards at the bottom, where it comes into contact with the fire D D. This construction favors rapid heating, adds to the strength, and allows the wort to drain more rapidly from the hops. B B represents a rake with teeth (or chains) which is kept turning round by a wheel, C, in order to hold the sediment in suspension, and prevent tho decomposition which would take place if the solid matter were allowed to settle on the bottom of the copper. The shaft of this rake moves in a stuffing box at top, and admits of being raised at pleasure by a chain passing over pulleys, as shown in the wood-cut. AA denotes the wort in the copper, and round the shoulder on the outside is placed the pan described on pages 35 and 36. In this part of the work a general account is given of tho apparatus used in wort coppers, with remarks on the comparative merits of close and open coppers. Dampers in the flues should be employed to regulate the draught of air and the consequent amount of heat that may be applied without injury

to the vessel. As a general rule the broader and shallower a copper is the more quickly will it heat the worts.

Mash Tuns.—In breweries of small extent the mash-tun is invariably made of wood; in large establishments iron tuns are not uncommon, but wood is for several reasons the best, as it is the cheapest, material. The false bottom, however, is frequently formed with advantage of metal plates. The shape of the tun should be slightly conical, with the narrowest part at top, and the staves should be quite two inches thick, both for strength and the better retention of heat. In addition to the description on page 16 of the mash-tuns in general use, it may now be stated that the mashing liquor is in most cases conveyed down the inner surface of the vessel by an upright trough or shoot, one side of which is formed by the mash-tun itself. This shoot enters the space between the false and real bottom, and the liquor which passes through it after filling the space rises up through the holes in the false bottom, and forces its way in amongst the goods. As a provision against the possible choking of the holes in the false bottom by thick, starchy, deposits from the worts, the outer side of the shoot is often pierced with minute holes, for a few inches from the top, in the same manner as the false bottom. Until the taps are set and draining begins these holes are kept closed by some contrivance, such as a sliding shutter or an inner trough, and when there is occasion to let off the worts from the top of the mash, the shutter or trough is pushed downwards and the wort admitted through the perforations, whence it passes to the space between the two bottoms and makes its exit from the tap.

When the false bottom is made of wood the holes should be formed by burning rather than boring, to avoid the risk of the wood shrinking after the first application of hot liquor. These holes, as before stated, should be funnel-shaped, the lower part about the third of an inch, and the upper part not more than one-eighth of an inch in diameter. When the several pieces are placed in their position against the sides of the tun they should fit closely together, leaving no chink between one another. The



appearance of one of the sections of a false bottom is shown in the annexed figure. Covers of the most simple and effective kind for mash-tuns may be made of a light movable framework of wood, over which canvas is spread, and from the edge of which curtains of the same material hang down over the sides of the tun.

In fixing the size or capacity of a mash-tun, it must be borne in mind that the space between the two bottoms is ineffective, and also that a considerable space must be left above the surface of the goods to prevent waste of the materials by splashing during the revolution of the machinery or the agitation with oars.

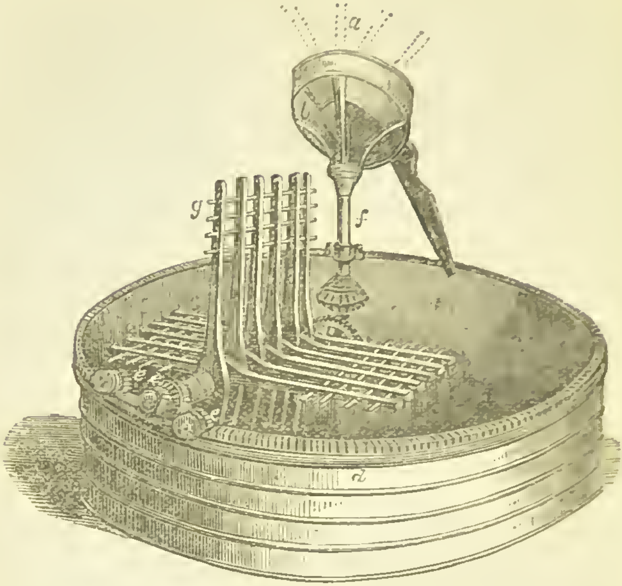
An inch between the bottoms is sufficient to ensure easy draining without risk of the holes becoming choked with solid matter from the mash. As a rule it is advisable not to mash higher than the point which stands at about one-fourth of the depth of the tun, reckoning from the top downwards to the level of the false bottom. In all cases, however, the extent of each mashing should be so regulated as to allow a clear space of from five to six inches above the surface of the goods.

A mash-tun should be capable of containing nearly four barrels for every quarter of malt to be brewed, reckoning, as above, that not much more than three-fourths of the entire capacity is properly available.

If the tun be much less than this proportional size, it will not be possible to use a sufficiency of liquor in the first mash to obtain the full extract of the malt, and thus the most advantageous mode of mashing cannot be practised.*

Three or more stop-cocks of two inch bore are inserted perpendicularly in the bottom of the tun. Seasoned Norway deal is recommended as the best timber for mash-tuns.

* See the general remarks on mashing in Chapter I.



A view of the ordinary modern mash-tun, with the rake-machinery and hopper attached, is given above. The supply of bruised malt descends through the hopper and shoot, *a b*, into the tun. On the upright pillar, *f*, a horizontal arm is affixed, which extends to the circumference of the tun. This arm carries a series of prongs or rakes, *g*, placed at right angles to the arm, and turning on it as a centre, but contrarily to each other. The appropriate movement, both of the arm along the cog-work on the rim of the tun and of the rakes around the arm, is given by a system of toothed wheels fitted to the central pillar, which is itself made to revolve by steam power.

Underback.—All that seems necessary to observe with regard to this vessel is, that it should be proportioned in size to the mash-tun, that it may be of any convenient shape, that it should be placed immediately below the mash-tun, and in as good a light as possible, so that the color and condition of the worts, as to transparency, may be judged of properly. But it is better, as was pointed out on page 94, to dispense with underbacks altogether, and run the wort into a wooden heater or spare copper direct from the tun.

Hop-back.—Hop-backs are usually square, and are made rather shallow, with cast-iron bottoms. The draining-plate or tray should be fixed at about a-fourth of the depth from the top. It is best, if it can be so arranged, that the hop-back should be placed just above the level of the first cooler, and as close to it as possible, so that the wort, as it is strained from the hops, may at once spread itself over a large surface and begin to cool.

Coolers.—There is but little to add to what has already been stated in the 1st Chapter (page 43, &c.) respecting these utensils. But it may be observed that the cooling space or area should be of such dimensions as to ensure that the layer or sheet of worts shall not on any occasion be of a greater depth than two, or, at the most, two-and-a-half inches. The sides of wooden coolers should be two inches thick, the bottom or floor an inch or an inch and a quarter; the depth about six inches. Close, sound, deal is the best wood for coolers. The inner surface should all be carefully planed, as the slightest roughness or projection favors the accumulation of dirt. A gentle slope must be given to each cooler to expedite the running off of the whole of the wort as soon as the plugs are loosed. Although a refrigerator may be employed, it is advisable that the worts should be deprived of a part of their heat by exposure for a short time in an ordinary cooler, but for this purpose half the quantity of cooling surface that would otherwise be necessary will suffice. When the temperature on the coolers has fallen to 130° F., the refrigerator should be brought into use.

In choosing a refrigerator it is important to see that it is so constructed as to admit of each length of tubing being easily cleaned out. This is generally provided for by making apertures at the bends, fitted with screw-caps, through which a long-handled brush may be passed. It is also of great consequence that the refrigerator should have the power of draining itself completely when required;* for if liquor, either wort or water, be allowed to remain in the pipes during frosty weather, there will be a risk of bursting when a thaw sets in; and in any case the carelessness or inexperience of the workmen when washing

* Which should be after each time of using.

out the pipes may lead to waste by running off the contained wort along with the water, or to an undue weakening of the worts by admixture with water. An efficient self-draining arrangement is therefore essential. Square bends are found to operate better than rounded ones. The whole framework, with its system of pipes, should be attached to balance-weights, so as to permit either end or side to be raised to any angle at pleasure, for facility of inspection or repairs.

In the larger and more powerful refrigerators a barrel and a half of cold water (54 galls.) will rapidly reduce a barrel of wort from a heat just under that of boiling to the temperature of the water itself. The rate of cooling is often as great as 1000 barrels an hour.

Fermenting Tuns.—Strong wooden vessels of circular shape are those most commonly used for holding the wort during the process of fermentation. Other materials are, however, sometimes employed with certain advantages, (see page 50). Vessels of a square form are not so easily cleaned or kept clean as round ones, and do not maintain the heat of the fermenting wort in cold weather so well as the latter.

It is requisite that the wood should be of considerable thickness—from two to three inches—and that the boards or staves should be closely joined and bound together with stout iron hoops. Without entering into the unsettled question, whether it is better to cover in the tuns or leave them open during fermentation, it may be remarked that there must be a dense atmosphere of carbonic acid gas above every gyle-tun, which effectually prevents access of air, while the yeast is in active operation,—that the loss of alcohol, if any, by exposure, must be very slight, and that brewers generally remove their worts to casks, or other nearly close vessels for cleansing, some time before fermentation would have so far slackened as to permit the air to penetrate the smaller body of gas resting on the wort. It is only when wort is through any cause kept in the gyle-tun after the yeast has ceased, or almost ceased, to work, that the protection afforded by a cover can properly be said to be essential to the soundness of the beer; but this is quite an exceptional case and one most unlikely to occur in the practice of brewing.

No precise directions can be given respecting the size of the fermenting-tuns. All that can be said is that the vessel or vessels must be large or numerous enough to contain the whole of the wort requiring to be fermented at one time, and that a spare or reserved vessel should be in constant readiness to receive extra quantities, and to provide for emergencies and changes in the mode of working; the tuns should be of sufficient capacity to hold all the freshly-brewed worts, and leave an unoccupied space of eight or twelve inches at top, so as to make room for the head of yeast which rises during fermentation. *It should be borne in mind that the height of the head of yeast is in proportion to the depth of the worts, without regard to the area of the vessel.* As a further precaution against the rising of the yeast a framework of boards to fit closely round the top of the tun should either be kept permanently attached to the vessel or ready to be applied as soon as the state of fermentation threatens an overflow.

The gyle-tuns should be fixed above the level of the ground, and the use of communicating lengths of metal pipes avoided as far as possible. Leather or gutta-percha hoses are the most suitable for cleansing purposes in a brewery. Regulators or attemperators for controlling at will the heat of the worts in the gyle-tun, consist usually of a coil of metal piping, fixed in the upper part of the vessel and descending only to the depth of one or two feet. No object would be served by continuing it further down, while it is always advisable to curtail the use of metals as far as possible in brewery utensils, so as to lessen the risk of galvanic action. Cold water, to moderate the fermentation when violent, or hot water, to stimulate it if languid, is passed through the rounds of the piping.

Casks, Stillions, Store Vats, &c.—No detailed account of these vessels or utensils, further than the general remarks given in the 1st Chapter, is necessary. In the fitting up of a brewery the owner will, of course, engage the services of experienced workmen, who are able in most cases to suggest the proper size and shape of all the articles they may be called on to construct or provide.

Malt Mills.—It is essential that the metal rollers should be of equal size, and that the moving power should be so applied as to cause them to revolve at the same degree of speed, otherwise the malt will be imperfectly and unevenly bruised. The supply of malt should pass through a wire-screen before it is admitted into the hopper of the mill, so as to exclude pebbles and dirt. When malt of much inequality of size is purchased, the larger grains will be too finely crushed by that setting of the rollers which is necessary to effect any disintegration of the smaller grains.

CHAPTER IV.

Fermentation.

Irregular fermentation in general.—The process of regular and healthy fermentation, with all its more obvious characteristics, has been sufficiently described in the 1st Chapter (*see* page 52, &c). It remains to offer some observations on the various kinds of unhealthy or irregular fermentation, and to point out the best remedies.

The use of unsound materials, injudicious heats in mashing, souring in the underback or the coolers, and inactive yeast or an insufficient supply of yeast, may be said to constitute the principal causes of defective fermentation.

Scrupulous cleanliness throughout the brewery is all-important. It is especially advisable to pass water through the wort pumps after each occasion of using them, unless the brewings are continuous, so that no trace of the wort of a previous brewing may be suffered to remain in the pipes and become tainted. Lime and lime and water should be employed freely in the washing out of utensils, particularly the coolers, and brewing should be abstained from as much as possible during hazy or foggy weather.

When unsoundness to any material extent has taken place in worts, the peculiar smell and taste will in most instances reveal the fact to the brewer. A weak infusion of *blue* litmus or archil is a very useful test for the presence of an undue amount of acid in the wort. Pour a few drops of the infusion—which may be obtained at any chemist's—into a wine-glass, and fill up with wort. If the wort be really sound, the mixture will turn a dull brownish red; but if the tinge be a bright red, then an excess of acetic acid or some other acid may safely be inferred.

Effervescence with carbonate of soda is also a simple and useful test. Dissolve a few grains of the soda in water and add the wort. Observe closely whether decided effervescence takes place, as denoted by a faint creaming of the surface. If so, the wort is injuriously acid.

Inactive fermentation.—The surest indication of a sluggish fermentation is the comparative absence of the true cauliflower head, as described on page 53, and the curling of the yeasty top into broad flakes hanging downwards. There is also a marked want of the pungent aroma or "stomach" which accompanies good fermentation, and there is felt to be a general mawkishness about the taste and smell of the liquid. Stale, inactive, yeast, or an insufficient quantity of yeast is the main cause of bad fermentation of this kind. Too high or too low a pitching heat may likewise occasion it, and there may be some more remote and hardly-suspected reasons for the defect, all of which it is the interest of the brewer to trace out.

If the evil is ascertained to have been produced by bad yeast no remedy seems possible as respects that brewing; if by a short supply of yeast, a partial cure may be effected by adding a fresh quantity and beating the whole well into the liquor: if by the prevalence of too low a temperature in the gyle-tun, send a little warm water through the attemperator and endeavour by this or other means to keep up the proper heat. Recollect that large, deep, masses of wort are highly favorable to the development and maintenance of a high temperature. A shallow body of wort in the gyle-tun rarely admits of uniform or satisfactory fermentation.

An excellent practical rule as regards the right fermenting temperature is, that when about two-thirds of the original gravity is shown by the Saccharometer to have disappeared or attenuated away, the heat should have reached nearly 70°, *and at no period should it be greater than* 74° *F.*

Boiling fermentation.—Of all irregularities this is the most serious. It arises in almost every case from unsoundness in the wort or from bad yeast. The head assumes the form of light, patchy, curls, with a bluish-white appearance, or it has a blistered aspect and want of depth and closeness. There is very little attenuation, and when the yeasty top disappears no second head rises in its place as in healthy fermentations, while after a time the contents of the tun seethe and simmer or even boil violently, as though a fire were applied beneath.

It will always be found on examining into the previous circumstances that this irregularity is to be ascribed to some important neglect, oversight, or mal-practice in the preparation of the worts. But, mouldy or unsound malt or yeast is the most common predisposing condition. Once boiling has fairly set in, nothing of any effect can be done to remedy the evil. The resulting beer is sure to be worthless.

Yeast bite.—The meaning of this term is explained in Chapter I., page 50. The heavy, disagreeable, bitter thus denoted, is liable to be produced in close fermenting tuns and is communicated entirely by the yeast, small portions of which dissolve in the worts. The continuance of too low a heat after the tuns have been pitched is also apt to infect the liquor with yeast bite.

Pale ale, even from the first houses, is often tainted with this nauseous flavor. The beer is often quite bright and pleasant to the eye, but the smell is heavy, and the persistent bitter renders it both unacceptable and hurtful as a beverage.

The treatment to be adopted is evidently to try the effect of fermentation in open tuns and to stimulate the heat of the gyles at the beginning of the process. A tolerable cure for the bite when it has declared itself, is to flatten the beer by a lengthened exposure to the air, and to bottle it off and keep a considerable time in a cool place before sending out to consumers.

Acetous fermentation.—This is commonly the result of too high a temperature in the gyle-tun, especially when maintained for any length of time in hot or foggy weather. There is always danger of the acetous fermentation setting in if the worts be allowed to remain above an hour or two at a temperature exceeding 75° F. It is doubtful, however, whether there is really a special kind of irregular fermentation to which this name is applicable, as the only observed characteristic of it is the development towards the close of the fermenting process of a large amount of acid in the worts, which had previously been sound.

The only cure, or rather preventive, is to restrain the temperature by proper means, and to avoid brewing in sultry weather.

CHAPTER V.

Management of beer in Casks.

New casks.—The astringent matter contained in the staves of new unused casks should be effectually removed before the casks are filled with beer; otherwise a very disagreeable flavor is certain to be communicated to the beer. A mixture of quicklime and water is found in practice to be the best "seasoning" liquid for this purpose. About a pound of quicklime will suffice per cask. Fill the cask with boiling water, introduce the powdered lime, bung close, and let the cask be rolled about. The cleansing fluid should be allowed to remain in the cask two or three days, and the rolling frequently repeated. The cask after being emptied should be washed out several times with boiling water to remove every trace of lime. Beer may then be safely put in, as soon as the cask has become thoroughly dry.

Soda is perhaps preferable to lime, but the latter is less expensive and answers sufficiently well.

Used casks.—Before putting beer a second time into a cask and previous to every occasion of filling, a complete examination and cleansing must be gone through by a process of scalding or steaming, and scrubbing. In large breweries the work of purification forms a distinct and most important department of the business.

Ingenious machinery by which each cask when placed in a cradle or frame is made to rock backwards and forwards or to revolve quite round on an axis or between supports applied to the outside of the heads, and thus to impart a churning motion to the cleansing liquor within, is now generally employed. Hot air is also applied to this purpose with good effect under the patent of Davison and Symington: short lengths of chain introduced into the cask, and suspended loosely from the bunghole, sweep round the entire inner surface as the cask rotates, and detach all adhering matter. In every instance the cask is rinsed out with beer of the quality with which it is intended to fill it. The details of the

apparatus in question cannot be understood without the aid of a diagram and a minute verbal description which would encroach too much on the space at command. But at almost every large brewery the system may be seen in daily operation.

Foul casks.—The blisters sometimes formed on the inner surface of the staves by the use of too strong a fire in the making up of a cask tend to collect and retain impurities deposited by the beer, and are thus a common cause of mustiness and foulness. Where these blisters exist—a fact which cannot be determined without taking out one of the heads—they must be cut off with an adze before the cask can be properly sweetened. A little chloride of lime dissolved in hot water will then remove every trace of ill odor. About four ounces of the chloride to a barrel of water will be sufficient. The addition of a small quantity of any strong acid, preferably muriatic or sulphuric acid, aids the process by liberating the gas from the lime more rapidly. The casks should be tightly bunged after the cleansing mixture has been poured in, so as to prevent the gas from escaping, and then rolled about. This is a very cheap and effectual mode of purifying casks. Chloride of lime can be obtained of any oilman or druggist. It costs about twopence a pound wholesale. When kept in stock it requires to be well protected from the air, as the gas slowly passes away if the vessel be left uncovered.

Of course, after cleansing with the chloride, the cask should be washed out several times with plain water.

For large fixed casks and vats which have become tainted, it will be more convenient to use water slightly tinctured with sulphuric acid (oil of vitriol), and after rinsing with this, to employ lime and water, followed by pure water as before.

Casks which remain foul, in spite of the treatment above indicated, should be unheaded, and all the obviously unclean parts pared away.

Another important benefit arising from the use of hard water in mashing is the protection afforded to the inner surface of the cask against the formation of vegetable mould by the gradual deposition of the lime salts of the water on the

staves. A coating or incrustation of mineral matter is thus induced which prevents the seeds of any kind of fungus from lodging in the pores of the wood and obtaining materials for its growth. The charring of the inside of the cask has a similar effect. Nothing is more essential in a brewery than a systematic "overhauling" and thorough purification of casks every time they are returned. Sending out beer in casks that have the least degree of foulness entails a certain loss of reputation and custom.

When casks after being cleansed happen to remain unfilled for more than one or two days, especially during damp weather, it is advisable to scald them afresh and let them become thoroughly dry before they are used. It is safer to rack at once into a newly-emptied cask than into one which is damp or stale.

CHAPTER VI.

Disorders of Beer.

Undue acidity.—Coarsely-powdered marble or limestone is the only unobjectionable remedy for an excess of acid in beer. The quantity to be used must depend on the degree of sourness, but any excess in the amount added above what is requisite will be of no moment, as the acid present will dissolve no more than is sufficient to neutralize itself, and the remainder, being insoluble until fresh acid is generated, will have no effect on the flavor or other qualities of the beer. Indeed, it is best always to employ a considerable excess of limestone, as any further development of acid will thus be rendered insensible by the immediate combination ensuing between it and the alkali. The powdered limestone is from its hardness slowly acted on by the acid of the beer; as solution takes place carbonic acid gas is given out in a small continuous stream, which maintains the liquor in a brisk, pleasant, condition; the vessel may be shaken (as indeed it should be occasionally), to promote solution of the powder, without stirring up a muddy deposit as would be the case if chalk were employed, and the slight bitterness of the harmless compound formed by the union of the acid and the lime is hardly to be perceived through the predominating flavour of the hop.

Strong, caustic, lime or soda, it should be observed, is not at all adapted for the correction of acidity, as it is deficient in carbonic acid gas, and communicates a flat, saltish, taste to the beer. Chalk dissolves too rapidly and renders the liquor muddy on the least disturbance of the vessel.

Egg-shells, oyster shells, and other similar substances are used in place of limestone, but with much less advantage or effect.

All beer to which any kind of alkali has been added to neutralize acidity should be speedily consumed, as by further keeping it has a tendency to become flat and contract a vapid taste. The addition of a little sugar, say 2 or 3lbs. to the hogshead, is useful in restoring fulness and sprightliness to beer which has been alkalized for sourness.

Ropiness.—This expressive name, as was observed on

page 59, is given to a peculiar, viscid, oily, condition of the worts, which results chiefly from the continuance of too low a temperature after the gyle-tuns have been pitched.* The finished beer is also liable to assume the same condition when it has been subjected to the action of finings and subsequently kept or stored a long time. Ropiness would in this case appear to be caused by a deficiency of tannin or astringent matter consequent on the use of finings, and to an accompanying excess of gluten. It is advisable therefore to defer the fining process until just before the beer is drawn off for consumption. As hops contain a considerable quantity of tannin, the introduction of a strong infusion of hops, or of a handful of the dry substance, into each cask, will often suffice to cure ropiness.

The following method of dealing with ropiness has been found successful. To each barrel of the beer add a quarter of a pound of bruised mustard seed rubbed up with a little warm water. Rouse well, and in a few days strew over the surface half a pound of fresh hops which have been wetted with hot liquor. Then in about a week or so introduce a quart of finings, and let the whole repose for a short time. This treatment, if it does not completely restore the beer, will at least fit it for admixture with a better article. But the blended liquor should be sent at once into consumption.

Some writers recommend the addition of a little infusion of oak-bark or catechu with a few hops. In a fortnight the beer is to be well rummaged and fined down the following day.

An injudicious blending of new and old beer is a frequent cause of ropiness.

MUSTINESS.—A musty flavor and smell may be in great part, if not wholly, removed by racking the beer into clean casks, and adding to each hogshead a decoction of one pound of new hops boiled in a gallon of the beer, and seven lbs. of freshly burnt charcoal. The latter should be coarsely broken up and the fine dust sifted off. Let the whole be well rinsed up every day for a week. Then stir in three or four lbs. of moist sugar, and allow to rest, closely bunged down, for a fortnight.

* Another cause of ropiness will be described in the Chapter on the use of Sugar in Brewing.

CHAPTER VII.

Use of Sugar in Brewing.

Sugar may be used as a partial substitute for malt, with in most cases some degree of saving to the brewer, and under proper management, without injury to the quality of the produce. But as a rule sugar is not resorted to on the large scale in ale brewing, except when malt is of poor quality and dear; it is, in fact, the scarcity of good malt that chiefly leads to the employment of sugar in brewing, although for the purpose of raising the gravity of worts to any desired working standard where from any cause the malt used does not yield well in the mash tun, sugar offers a very ready and convenient material.

Sugars of course vary in price and character as do the different qualities of malt, but in the end the best (for the purpose) will be found the cheapest, and it should be borne in mind, that bad sugar will not any more than bad malt yield sound or palatable beer.

Proportion.—As already stated, from 210 to 220lbs. of good raw sugar may be taken as the average equivalent of a quarter of malt, so that for every quarter of malt left out in a brewing about 215lbs. of sugar of this description may be substituted with equal effect.

It is hardly possible to replace more than one third of the malt by ordinary sugar without endangering the soundness and injuring the flavor of the ale. In the brewing of Stout or Porter, however, for quick consumption, the proportion may be safely increased to one half.

Dissolving the Sugar.—Many brewers make it a practice not to add the sugar until the malt worts are collected in the copper, but this method is open to the objection, that it is difficult to mix the solid sugar with the wort unless the latter be boiling at the time, so as to prevent it from sinking in part undissolved to the bottom of the copper and there adhering to the metal and becoming burnt: and when boiling has begun, the addition of the sugar checks

or arrests the process for a little, and this should be avoided, however short the interval.

Others put their sugar into the mash-tun at the time of mashing, to ensure its being thoroughly dissolved and blended with the malt extract as fast as that is formed. But the best plan is to put the right quantity of sugar into the underback just before setting the taps, and run the hot wort upon it, when, with a little agitation, perfect solution and intermixture will ensue.

Boiling.—The wort should be boiled the same time, and the gravity and the quantity of hops should be regulated in the same manner as when all malt is used, it being borne in mind that in ordinary cases every 215lbs. of sugar may be reckoned as representing one quarter of malt.

Fermentation.—In conducting the fermentation it is important to bear in mind that sugar-wort, owing to the comparative absence of nitrogenous matter, ferments with greater difficulty than pure malt wort, and that to provide for this, the pitching heat should be lower, and that more yeast must be used, than in the case of worts from malt only. It will, as a rule, be necessary that the tuns be pitched about two degrees lower than usual, and that half a pound more yeast be added per barrel. The reason for the extra quantityof yeast was adverted to on page 52.

Sugar beer does not keep so well as that made entirely from malt, because of the difficulty of checking the after-fermentation in solutions of sugar, in which material little or no gum (dextrine) is present, the gum of malt wort passing but *slowly* into sugar and thence into alcohol, &c., after the beer has been cleansed and stored. For this reason, brewing from sugar is most advantageous when practised on a comparatively small scale and in cold weather.

Gum undergoes fermentation slowly, owing to its necessary transition as a first step into the condition of sugar, so that for months or even for years after all the original sugar of the wort has been decomposed, the evolution of carbonic acid gas from the still fermenting liquor keeps up a briskness and freshness in the beer, while by excluding air as much as possible the risk of

acetification is lessened. In all scientific brewings, therefore, the relative proportions of gum and sugar in the wort should be determined by some ready method. There is however no expedient available except that of throwing down the gum by means of spirits of wine, and this from its costliness is seldom resorted to. If the experiment be made in a graduated glass tube, the amount of greyish deposit caused by the addition of the strong spirit, when compared with the total bulk of the liquid operated on, will indicate very closely the relative quantity of gum contained in the wort. The stronger the wort the less alcohol will be required to effect the precipitation.

The Saccharometer affords no discriminative test of the quantity of gum contained in a sample of malt wort, as the instrument is buoyed up by whatever gives density to the liquid, whether it be wholly gum, wholly sugar, or a mixture of the two. When a brewer wishes to promote the conversion of gum into sugar, he will best effect his object by keeping up the heat during mashing and prolonging the operation, or, more simply, by preserving the drawn-off wort for a few hours in a boiling back or spare copper at a temperature not below 165° F.

In warm weather the wort should contain nearly twice as much gum as in winter, to ensure which the mashing should be performed at lower heats, and the usual period of mashing should be shortened. Hence, the danger of brewing from sugar in hot weather.

As a general rule more sugar is necessary when only small quantities are brewed at a time, since the loss of heat is relatively greater in small masses. Sugar may therefore be safely and advantageously used by brewers who work on a limited scale, especially when the malt yields a wort deficient in natural saccharine, and they do not aim at producing ales of the finest flavor.

It is important to observe, that if wort consisting chiefly of gum be fermented in very cold weather or with an insufficiency of good yeast, or if the temperature happen to rise too high, a dull, languid, action will ensue accompanied by what is called the *viscous* fermentation, and the beer will become ropy and spoil.

To illustrate the saving that may under ordinary

circumstances be effected by the use of sugar, when that material is to be had at a reasonable price, an example is appended showing the comparative cost when malt at an average price is replaced to the extent of one-third by sugar of medium quality.

9 qrs. of malt, at 50s. per qr......		22 10 0
But, if on the basis that 212lbs. of sugar are equivalent to a quarter of malt, only 6 qrs. are used, and the remainder replaced by 636lbs. sugar, the cost will be—		
6 qrs. malt, at 50s. ..	£15 0 0	
636lbs. sugar at, say, 21s. per cwt.......	5 19 0	
		20 19 0
		£1 11 0

There is, therefore, at the average prices above quoted, a saving of £1 11s. 0d. in using one-third of sugar in place of malt, on a brewing of 9 quarters.

If a finer description of sugar be used, say such as is suited for ale brewing, at the average price of 25s. per cwt., the saving above exemplified will, of course, be reduced in amount, if not wholly neutralized. But it has to be considered, that when the quality of sugar is better, a smaller quantity will suffice as an equivalent to the malt displaced; so that on the whole, even when ales are brewed, there will be a decided saving by the employment of sugar, unless the price of the latter is unusually high.

The various kinds of Saccharum (Glucose, hard and soft, Maltose, &c. &c.) yield undoubtedly a fine beer of good keeping quality; but where cost is studied, ordinary sugar will be resorted to as a cheaper material, yielding excellent results under careful management, and well adapted for partial use in the manufacture of beers or porters commanding a quick draught.

CHAPTER VIII.

EXAMPLES OF ONE-QUARTER BREWINGS.

N.B.—For larger brewings let the quantities of hops, liquor, &c., be doubled, trebled, or increased in any other required proportion, according to the scale given in these examples.

No. 1.—ORDINARY MILD ALE.—*Materials.*—Pale malt, 8 bushels (measured before crushing*); East Kent Hops, 5lbs.

Operations.—Let the malt be crushed the day before mashing, and kept ready in dry sacks.

At 5 o'clock morning, light fire under copper and bring liquor to the boil; allow to boil gently a quarter of an hour. At 7 o'clock run into mash-tun a barrel and a half of liquor just off the boil, and when cooled down to 168°, add the grist by degrees, briskly stirring all the time. After the whole of the malt has been put in, continue the mashing for at least half-an-hour, and then turn on from under the false bottom of the tun one barrel more liquor at 180°, keeping up the heat to 185°. Prolong the mashing for three-quarters of an hour, cover up close, and let the goods stand two hours, after which set the tap, sparging on at the same time half a barrel of liquor at 190°. Let all this be drawn off pretty close, when there should be two barrels of wort in the underback. Pump up immediately into wort-copper. Next shut off the draining taps, and mash again 15 minutes with two barrels of liquor at 185°. Allow to stand twenty minutes to settle, then set tap and sparge as before a half-barrel of liquor at 190°. All the liquor required will now have been used, and the second wort, if the malt be good, should, when fully drawn off, yield $2\frac{3}{4}$ barrels in the underback.

* A bushel of malt measures when bruised moderately coarse about a bushel and a quarter.

If the wort copper is large enough to contain and boil the produce of the two mashings at one time, with the whole ot the hops, so much the better; if not, the first two barrels, the gravity of which ought to be 32lbs. per barrel, may be boiled an hour and a quarter, with nearly four-fifths of the hops, that is 3¾lbs., as calculated on the principle explained at page 39. The second wort of 2¾ barrels at the gravity of from 22° to 25°, should then be boiled two hours, or a little longer if the body intended to be given to the beer should demand it, with the remainder of the hops, viz., 1¼lb. After straining from the hops and cooling, the first wort will produce 1½ barrels in the gyle-tun at a gravity of 111°, and the second wort at least two barrels at 33°. For wort of the present gravity the pitching heat should be 61° and the quantity of yeast 1lb. to each barrel, or perhaps 1½lb. if the yeast is stale or inactive.

At no period of the fermentation should the heat be suffered to become higher than 74°. When this point is reached, cleanse into casks, as the attenuation will then probably be down to 36° or 39°. Should the fermentation appear sluggish during any part of the process, add about half-a-pound more yeast per barrel, and rouse every two or three hours until the head rises properly.

No. 2—STRONG ALE AND TABLE BEER.—*Materials.*—Pale malt, 8 bushels; strong Farnham hops, 12lbs.

Follow the directions in the first example as to heats and quantities of liquor, except that in sparging, 1½ barrel should now be used instead of half-a-barrel. There will thus be three barrels of wort in copper at a gravity exceeding 69°. Boil this an hour and three-quarters with the whole of the hops, when it should indicate about 33 or 34lbs. per barrel. At this density the wort should, when cooled to 59°, be fully 97°, owing to the evaporation, and the quantity in the gyle-tun should amount to rather more than two barrels.

As soon as the first wort is well drained-off from the goods in mash-tun, turn on 2¼ barrels of liquor at 175°, mash 15 minutes, and let stand 20 minutes more; when run off there will be 2½ barrels. This is the second wort, and ought to indicate a gravity of at least 17°. Boil with

the hops first used an additional 2lbs. of fresh hops from $2\frac{1}{2}$ to 3 hours. After cooling the gravity will be 31°.

The first wort for the strong ale should be pitched at 59°, with $1\frac{1}{2}$ lbs. good yeast per barrel, or 2lbs. stale. Do not let the heat rise above 75°, as in the former instance. Attenuate down to one-third of the original gravity, and skim off the head every two hours until it almost ceases to rise. More attention is necessary in the fermentation of strong than weak worts, for in the former case, after the second day, it will generally be found requisite to rouse continually, perhaps every three hours, in order to quicken the fermentation and carry the attenuation sufficiently low within reasonable time. When the last head, of less than an inch in thickness, is thrown up, cease skimming, allow the wort to repose in tun a couple of days, then cleanse into casks. No finings will be needed. Leave out the bungs for one or two days, then put into each cask a $\frac{1}{4}$lb. of dry, fresh, hops and bung down closely.

This ale will be in excellent condition at the end of a week.

The wort for *table beer* may be pitched at 61°, with 1lb yeast per barrel. Do not attenuate beyond the half of original gravity, viz., 31°. When down to about 17° cleanse, and keep casks constantly filled up.

CHAPTER IX.

Pale Ale and Bitter Beer.

It is commonly supposed that Pale Ale and Bitter Beer of the finest quality cannot be brewed elsewhere than at Burton-on-Trent; but it will here be shown that with proper management, a minute attention to details, and the use of carefully-selected materials in the right proportions, it is within the power of any brewer, in whatever place his business may be carried on, to manufacture either of these popular malt-liquors of as good a quality in every respect as the renowned produce of Burton.

The properties of the spring water obtained in Burton and the neighbourhood have no doubt, as previously observed in this work, some effect in promoting the natural clarification of the beer and in conferring upon it the keeping properties for which it is so justly celebrated. Apart, however, from the undoubted influence of the Burton water, or water of similar composition, there can be no question that the great secret of success in pale ale brewing lies in the use of selected pale malts and an abundance of the finest hops. No portion of common dark sugar or quassia, or of other substitutes for malt or hops, is allowable in the manufacture of pale ale, as the least deviation from the proper materials or mode of brewing must infallibly injure the flavor and fineness of the beverage. Those who may not care to take the trouble of having the water of their locality tested by a competent person, and if it should be found wanting in the requisite saline ingredients to have the defect remedied by impregnation with gypsum or marl, can nevertheless brew unexceptionable pale ale and bitter beer from the water they have at hand, provided such water is moderately hard, and free from

all decaying organic matter. As it is generally required that bitter ale should be pale or at the most of a light amber tint, care must be taken to obtain a sound but pale malt, as many malts, although sufficiently pale, do not possess the thorough soundness without which the ale will not keep; indeed it will be preferable to use a somewhat darker colored malt if there be the least doubt as to the soundness of a paler sample.

The strength of bitter ales varies considerably; some of the Burton brewings shew an original gravity as high as 72°, but the generality range from 56° to 64°. The heats for mashing, owing to the different degrees of hardness of the waters used by brewers, are seldom uniform, but when brewing bitter ale with a comparatively soft water, 168° for the first mash will be found quite high enough, whereas when the liquid is very hard a much higher heat is necessary—from 174° to 178° may be considered as the maximum temperature. The duration of the first mash should be two hours, and of the second one hour; this will be long enough to get a good extract out of the malt. It will be found advantageous, as a general rule, if there be any suspicion that the water contains the least impurity, to heat to the boiling point, and after a few minutes' brisk ebullition to let it cool down to the desired heat.

The next thing to be considered is the quantity of liquor to be turned on for the first mash, remembering that the stronger the beer to be produced, the less is to be turned on each mash; but as bitter ale is not required of a great strength, 2 to 2½ barrels per quarter of malt used is the right quantity for the first mashing. For the second mash 1 to 1½ barrels per quarter, at 180° to 188°, will be enough. A certain quantity of liquor will have to be added by sparging, as the two first worts will not be enough for the copper, about 5 barrels per quarter mashed being required for a 22lb.-beer.

Next comes one of the most important items in the bitter ale, viz., the HOPS. For some of the bitter ales brewed, large quantities of foreign hops are used, but as none of these are equal to the English in point of

delicacy of flavor, foreign hops should be very sparingly employed. Choice Bavarians may be used to the extent of one-third of the whole quantity, and it will be found best to make up the other two-thirds by equal quantities of the finest East Kents and Farnhams. The quantity of hops per quarter of malt must depend on circumstances. For a beer of 61° gravity for home consumption 18lbs. per quarter will be ample, but if intended for shipping, or if the ale brewed be stronger, more must be used. For an export beer of 72° gravity, 21 to 23 lbs. of hops per quarter will be required.

The worts being now in the copper, the important question presents itself, "How long shall it be boiled?" To this it may be answered, that as the object is not to get all the rank, but only the delicate flavor out of the hops, 1 hour to 1 hour 20 minutes will be quite long enough. If the wort has to be boiled at twice instead of all at once, it will be best to put three-fifths of the hops in the first copper and the remainder in the second; the boiling ought not to be longer than 1 hr. 30 min.

The worts should be cooled to 55° before the gyle-tun is pitched, as in bitter ale brewing it is required to carry the attenuation low, and this temperature will give plenty of room to rise in heat, without risk of getting too high.

As respects yeasts, from 1½ to 2 lbs. per barrel in tun is is the proper proportion in ordinary cases; but the amount varies, it being sometimes needful to use as much as 3 lbs. per barrel.

When the gyle in the tun has attenuated down to 28° gravity, and the heat risen to about 70°, the worts will be ready for cleansing in the ordinary way.

When the beer is ready for racking, which should not take place till it is quite bright, 1 lb. of hops per barrel should be put in each cask, and should consist of equal quantities of Bavarians, and either Farnhams or Kents. The hops should be well broken up together, so that the beer may get to every part of them; if for shipping, 1½lbs. per barrel will be required.

The gravity of the ale at racking ought to be about 14°. The casks into which the beer is put should be scrupulously clean, as no ale so readily contracts foulness in the cask as bitter ale.

It will be very advantageous to brew a mild ale the same day after the bitter ale, so as to use the hops again, of which (without any fresh addition) there will be enough for a brewing of the same length. The beer, however, will not admit of being kept so long as the bitter ale.

The bitter ale will not be fit for use till about two months after brewing, and will be found the better for being kept much longer.

CHAPTER X.

Porter Brewing.

It may be accepted as a general maxim, that Porter and Stout cannot be brewed advantageously on the small scale, owing to the difficulty of maintaining the high heat and rapid fermentation which seem essential to the production of the true porter flavor, except where large bodies of materials and vessels of appropriate magnitude are employed.

As the present work is designed chiefly for the use of the smaller class of brewers, only a few general remarks therefore will be offered on the subject of this chapter.

The qualities which characterise what would be termed good porter or stout, in the present condition of the public taste, are — a light, brown color, fulness on the palate, pure and moderate bitterness, with a mixture of sweetness, a certain sharpness or acerbity without sourness or burnt flavor, and a close, creamy, head, instantly closing in when blown aside.

Porter and Stout are now prepared almost exclusively from pale and roasted malts, the use of brown and amber malt being confined to a few of the most extensive and best known porter breweries. But although on the score of economy and simplicity there is an advantage in brewing from pale and black malt only, it cannot be doubted, judging from the practice of the great porter-brewers, that to obtain the true porter flavor, a certain proportion of amber or slightly scorched malt should enter into the composition of the grist.*

When pale and roasted malts are alone employed the grist is usually made up of 9 bushels or quarters of the former to 1 of the latter.

If brown and amber malts be introduced, the best proportions appear to be, 9 of Pale, 5 of Brown, 5 of Amber, and 1 of Black.

* See the observations on this subject, pages 11 and 12.

Slight modifications of these quantities are of course admissible at the discretion of the brewer, according to the varying quality of the materials, and the taste of the locality.

The hops used in porter brewing should be strong and thick blossomed, rich in condition, dull in color, and of well matured growth. Hops generally are improved by eight or ten months' keeping, for when new they do not yield their bitter apart from harsh and disagreeable extracts. 8lbs. or 9lbs. of good hops, per quarter of malt, will suffice for porter intended for home consumption; 10 lbs. or 11lbs., for exportation. No other black malt should be used than such as is made of good barley, thoroughly germinated and possessing a sound kernel of a uniform dark chocolate color. Roasted malt of this character consists chiefly of burnt sugar and mucilage, which impart an agreeable odour to the beer, and being almost entirely soluble, darken the worts to any extent that can be desired; but the ill-malted and inferior kinds are worse than useless, creating numberless obstacles in the mashing process.

London Porter has a gravity of from 56° to 67°; and ordinary Stout, for town consumption, from 69° to 78°; stronger beer is usually exported, or sent into the country.

In preparing the worts a stiff mash should at first be made, and after an hour's agitation the remainder of the water should be added at a high temperature, giving a total of about three barrels of liquor per quarter of grist. Then continue the mashing for half an hour, and cover up the tun and let the goods repose for fully two hours. Next remove quickly to copper and boil with hops. The second and other worts are to be obtained with the same proportions of water and afterwards treated in precisely the same manner as in ale brewings. Owing to the carbonization which some of the malt has undergone in the process of roasting, the heat of the mashing liquors may without danger of setting be rather higher than when the grist consists wholly of pale malt. But as the proportion of roasted malt is but small, it will hardly be

prudent in any case to allow the temperature of the first mashing liquor to exceed 170° : the second may, as a rule, be as high as 185°.

Some of the large porter brewers are in favor of long boilings; but it has already shown in this work, that protracted boilings do not add to the keeping quality of the beer, nor does the gravity increase in direct proportion to the amount of water evaporated. If much of the sugar be caramelized by the heat of the copper, there will be a disagreeable bitterness and a want of the soft fulness characteristic of good porter.

Porter wort therefore ought not to be boiled a longer time than ale wort—that is, from one hour to one hour and a half for each wort, exclusive of any unavoidable boiling for increase of gravity. One chief object brewers propose to themselves in boiling so long, is to extract all the bitter from the hops; but this may be best attained by first steeping the hops several hours in water heated to between 140° and 170°.

The general method of proceeding in the fermentation of porter differs from the cool and gradual process so essential to the preservation of the sweet flavor and richness of ale. Porter owes much of its tart and astringent flavor to a high, rapid, fermentation, which lessens the density without diminishing the high flavor drawn from the materials. This rapid process also suits the extract of brown malt, which, being less dense than that from an equal quantity of pale, cannot support a vigorous fermentation, while the yeast being more rapidly thrown off, leaves the beer clear and durable. The pitching temperature should be taken between 64° and 68°, except in summer, when it may be taken as low as possible; the heat of the gyle should be curbed between 74° and 78°, and the attenuation not carried below 28°, or 31° before it is cleansed. The fermentation in the tun will ordinarily be concluded in about 48 hours. When 19° or 17° gravity are left unattenuated, the liquor may, if fine, be vatted in a large body, to improve and mellow it. Should the gyle, after it is vatted, exhibit a disposition to fret, leave the manhole open for a few days; if the disorder do not abate, throw into it the spent hops from one or two gyles, which will usually check it. A stock of

old porter, sufficient for staling twelve months' consumption, should be kept on hand. It should have undergone the same attenuation as keeping beers, and have been fined from the yeast before starting. The old porter should be mixed in the proportion of one-third with all sent out; it will produce a beverage of uniform strength, having the flavor of age, fine in summer, and full of tone in winter. The proper proportion must depend, however, in a great measure upon the taste of the customers, as no specific rule can be of universal application. Never send out Mild Porter entire, as the admixture, if done by others, may spoil the article, and the fault be charged upon your management. Considerable loss by absorption and evaporation takes place in the store, according to the time occupied in storing: the use of wooden vats greatly aggravates this evil; and the smaller the vat, the greater the waste. A vat containing fifty barrels will, in an ordinary store, lose about two gallons yearly; while one containing five hundred barrels will not, in the same time, show a deficiency of more than 5 gallons. Much of this loss may be obviated by providing each vat with a small valve opening outwardly and loaded, on the principle of a safety valve, with a weight of 1 lb. to every square inch. The best cellars are those which are slightly humid, as dry cellars are found to evaporate full fifty per cent. more of the spirituous portion of the beer than those which are damp. They should be dug as deep as local circumstances will admit.

Porter, brewed for exportation, with 10lbs. or 11lbs. of hops per quarter of malt, has a density of from 69° to 89°. Prior to shipment, it ought to be vatted ten or twelve months; and, as the motion of the ship and the heat are apt to set it at work again, it is necessary to flatten it before the final racking, by leaving the man-hole of the vat open for three weeks. To guard against premature acidity after its arrival at its destination, all matter tending to turbidity should be precipitated by finings, and the liquor should not be racked until it has become perfectly bright.

Cane-plugs, owing to their porosity, or plugs made from a peculiar red oak which is nearly as porous as cane, afford additional security to the casks when in transit by allowing part of the generated gas to escape.

CHAPTER XI.

Small Brewings with Limited Conveniences.

General Remarks.—In providing for the brewing of small quantities of ale, where the utensils and other conveniences at command are few and perhaps hardly adequate to the occasion, the point chiefly to be regulated is the relative size or capacity of the mash-tub, and copper. For an eight-bushel mash the copper should be capable of holding from 90 to 96 gallons. The mash-tun (from the fact of the space occupied by the malt when mashed being only about one-third of that occupied by its bulk previous to mashing) need not be of larger content than about $3\frac{1}{2}$ to 4 barrels. Of the 96 gallons of liquor used in the mash, about 26 gallons will be retained by the goods in the mash-tun, leaving only about 2 barrels for the first wort. During the time the first wort is draining from the mash-tun, the copper is again charged with liquor and got quickly ready for the second mash. The quantity of liquor to be used in the second mashing is determined by the intended strength of the ale, and by the fact of whether table or small beer is to be made afterwards. If there are to be only two mashings, it is advisable to have the second a long mash, for the purpose of obtaining the greatest amount of extract, and then by slow boiling to reduce to the required strength or quantity. It may also be observed, that there being only 2 barrels of the first wort and the capacity of the copper being less than 3 barrels, it will be convenient to add about $\frac{1}{2}$ a barrel of the second wort to the first boiling which will equalize the two boilings to about $2\frac{1}{2}$ barrels each. Besides the loss occasioned by boiling for increase of strength, there is a further loss from the quantity of wort held by the hops, which with good fresh hops will amount to about $4\frac{1}{2}$ pints for each pound of gravity; but the strength of the wort so retained is given out to the

second wort, and the gravity of what the hops keep back is only equal to that of the second wort, and this will finally be imparted to the table beer, should any be made.

The expense of a special gyle-tun may be dispensed with, as in all ordinary cases the mash-tub, if it has a close cover, and if it be emptied and well washed while the wort is cooling, will answer the purpose; or, should a separate fermenting vessel be preferred, it will be sufficient to procure a brandy or wine-cask, proportionate in size to the quantity to be fermented. In winter this cask may be placed in a warm situation, and thus assist materially the process; or, in summer, in an equally advantageous cool position. This cask should be provided with a very large bung-hole, into which should be tightly fitted a hopper, similar in its construction to the hopper used with a grinding-mill, for the addition of yeast. The neck of this hopper should be fitted with a slide or long plug, for the purpose of removing the hopper and its contents without disturbing the fermenting cask. The cask then being made air tight by affixing over the aperture a piece of strong paper with paste, attenuation will still go on. A wort indicating 83° gravity, when the hopper was removed gave only 47°, and the cask being sealed the attenuation continued until reduced to 25°.

Previously to the bulk of the wort being placed in the fermenting-cask, the yeast should be mixed with a small portion of the wort and run into the vessel; the wort when ready, should then be turned in upon the ferment, till it reaches halfway up the hopper; the fermentation will then proceed rapidly and uninteruptedly, until in the judgment of the brewer a sufficient attenuation has been reached.

DIRECTIONS FOR MANAGING A BREWING OF TWO QUARTERS OF MALT.

As by far the greater number of licensed brewers mash less than three-quarters of malt at one time, and are for the most part unprovided with the expensive appliances

and conveniences which are essential to the success of operations on the large scale, the best method of conducting a two-quarter brewing in the absence of some of the proper facilities will be here described in full detail from the beginning to the end of the process.

Two quarters of malt should yield four barrels or one hundred and forty-four gallons of good ale, and one barrel and a firkin, or forty-five gallons, of excellent table beer; or, if the ale and table beer worts be mixed together, five barrels and a fourth of weaker ale. The malt should be crushed into a meal of uniform fineness, and put by to mellow at least 30 hours before the time of mashing. When the water in the copper is brought to nearly boiling point, one hundred and thirty-four gallons are to be turned into the mash-tun with as much cold water as will reduce the heat to 178°. Ten gallons of cold water will bring up the whole to one hundred and forty-four gallons: equal to nine gallons per bushel of malt. One person must now gradually let down the malt from the hopper into the liquor, while another is employed in mixing them thoroughly together. This mashing operation will occupy fully half an hour, as every lump must be completely broken, and the whole reduced to a uniform consistency. Now place the cover on the tun, and over it throw the empty malt sacks, and a blanket to retain the steam and keep the mash hot. Refill the copper with water, to get hot for a second mash, or for a sparge. After the mash-tun has remained covered for the space of nearly two hours, turn on the three taps partially, and run the wort into a pail placed in the underback. As soon as it runs perfectly clear the pail may be removed, and the wort allowed to run direct into the underback, while the contents of the pail are returned into the mash-tun, and the taps turned on by degrees, for the freer passage of the wort into the underback. If the wort run quite clear, and form a transparent, frothy head, some inches high, the proper mashing heat has been chosen; but if the wort be turbid, and tinged with red, it is a sign that the liquor was too hot; and if it descend frothless and dead, it is a proof that the liquor was too cold. The heat of the wort at the time it is discharged into the underback, should not be under 144°

Remove the cover of the mash-tun, and, before the wort sinks below the surface of the grain, shower over it, through a coarsely-perforated watering pot, at slight intervals, about one hundred and twenty-eight gallons of of liquor, heated to about 188°. This process, termed *sparging* is to be preferred to a second mash. From the first running, ninety-six gallons of wort, at a gravity of 26lbs. per barrel, are drawn off before the taps are shut; and ninety-eight gallons more, at a gravity of about 61°, are subsequently drawn from the spargings, which together amount to one hundred and ninety-four gallons of an average gravity of 67°. This quantity will be reduced fully one-fourth by the process of boiling, by absorption of the hops, and evaporation in cooling, and will eventually measure little more than the one hundred and forty-four gallons required; but while it will thus have decreased in quantity, it will have proportionably increased in gravity, and will prove, if properly fermented, a stout and good-bodied keeping ale.

Meanwhile, the copper should have been refilled, the water boiled, and, when cooled to a temperature of 198°, forty gallons sparged on the grains for the table beer wort, and allowed to remain on the mash for the space of one hour and a quarter. Before the copper is empty, the fire is to be damped, and the whole of the ale worts from the underback turned into the copper as quickly as possible, with 8lbs. of the best hops: the fire is then rekindled, made to burn briskly, and the wort to boil as quickly as possible, and kept so boiling that it may the sooner break and fine itself. After it has boiled for thirty or forty minutes, the wort will probably be broken, and much of the goodness of the hops extracted: the remaining 8lbs. of hops are now introduced, and the boiling continued for thirty minutes more. By this mode of dividing the hops, an aromatic flavor is imparted to the ale which greatly improves it, while the hops are more valuable for the table beer wort. The boiling being finished, and the fire damped, the wort is run off upon the cooler through a large hair sieve, and should be well stirred in the copper while running, to prevent the hops from subsiding to the bottom. In the meantime, about 70 gallons of the table beer wort, at a gravity

of about 6lbs. to the barrel, have been run into the under-back, and, with the hops, quickly turned into the copper, and the fire renewed. This wort is then made to boil quickly for the space of one hour, and turned off on the coolers in the ordinary way; or as it is very desirable to increase the gravity of so weak a wort, it is allowed to remain all night in the copper, with the fire damped, which will further decrease the bulk by evaporation to from forty-eight to forty-four gallons, according to the means employed.

As the first mash in which nine gallons of water were used to every bushel of malt, may not have quite extracted one-half of the available saccharine, it has been supposed that the ninety-six gallons drawn off the first running had a gravity of 72°, and also that the ninety-eight gallons of the second running indicated a gravity of 61°. Were it possible, therefore, to extract the whole of the remaining saccharine by the table beer mash, this would give to the seventy gallons drawn off a gravity of 28°; but as this is not possible, the gravity, after the operation is concluded, instead of 28°, will be 17° only: now, as this quality of wort is very weak and poor, and contains a much smaller quantity of the sugar of malt than an equal weight of either of the previous runnings, it may be necessary to raise it to 25° or 28° by the process of evaporation described, which will reduce the bulk to about forty-four gallons.

To sum up the steps already taken, there were turned into the mash-tun one hundred and thirty-four gallons of water nearly boiling, and to this were added, ten gallons of cold water, to reduce the heat to 178°, being one hundred and forty-four gallons in all; next were turned into it the two quarters of malt, each bushel of which absorbed full three gallons of water (forty-eight gallons), leaving only ninety-six gallons free, which is all that could have been drawn off the first mash, had the goods been run dry before sparging; and as the goods will continue to retain this quantity in the subsequent worts, the brewer can reckon on drawing off only the same number of gallons as of water sparged on. The sparging commenced as soon as the taps were opened for the first

wort to run, and continued until ninety-six gallons had been drawn off; the quantity of liquor sparged on during that period was one hundred and twenty-eight gallons, which remained on the mash after the taps were turned off. The taps being again opened, ninety-eight gallons were drawn off from the one hundred and twenty-eight, thus leaving thirty gallons on the mash; forty gallons of liquor were then sparged on, to make up the seventy gallons required for the table wort.

The mean gravity of the ale worts is arrived at in the following manner:—

	First Wort.		Second Wort.
	96		98
	72		61
	192		98
	672		588
Galls.			
96	6912		5978
98	5978		
194)	12890	(66°	
	1164		
	1250		

A pint and a half of good brewer's yeast will be wanted to ferment the table wort, which must be cleansed at the end of twelve hours; one gallon of good yeast will suffice to ferment the ale wort. Two quarts of the yeast are dissolved and mixed with two gallons of ale wort at a temperature of 87°; and when fermentation has commenced in this portion, another gallon of wort is added; and just before the worts are cooled down to the proper temperature, which should be as low as possible in warm weather, 62° in mild weather, and 74° in very cold weather, this ferment is poured over the surface of the gyle-tun, the worts let down upon it and well incorporated. The other two quarts of yeast are added as occasion may require, to stimulate the fermentation, though care must be taken not to over-stimulate, as fermentation should be very gradual, especially at first. The slight white cream

which floats next morning on the surface is mixed up with the mass; a sample is then drawn, and examined by the Thermometer and Saccharometer, when a slight increase of heat will appear, attended with a decrease of gravity. Towards evening, should fermentation be languid, a small portion of the remaining yeast is added, and well mixed. The second day, should the cauliflower head appear with patches of dark brown yeast on its surface, it must be carefully removed, lest it incorporate and impart a bitter and unpleasant flavor to the ale; the cream is then mixed with the mass, and a sample taken out and examined by the Thermometer and Saccharometer, when a further increase of heat and decrease of gravity will be detected. The gyle is then allowed to remain undisturbed as long as its foamy head continues to retain a light white color; but should a head be formed of a uniform dark brown color, exhibiting a tendency to sink, it is skimmed off; and if the gyle have not reached the degree of attenuation required, which, according to the temperature of the air, should range from 39° to 19° (the more matter being left unattenuated the colder the weather is at the time of cleansing), it is in such a case again roused up, and skimmed every two hours, until this point is reached.

CHAPTER XII.

Bottling.

Before proceeding to bottle malt liquor of any kind, it is important to ascertain whether it is in proper condition. If, on drawing out the vent peg from a cask the beer should spout out with any degree of force, it is a sign that the liquor is still too active to be bottled with safety. In this case it will be necessary as a first step, to flatten the beer by leaving out the bung and allowing free access of air for one or two days, according to the state of the weather and the briskness of the beer. But a preferable method, especially when operating on the small scale, is to run off the beer as it is into bottles, and to let them stand uncorked for twenty-four hours or longer. Any quantity that may have been lost by frothing over or by the subsiding of the froth is then to be made good with beer from the cask, the bottles being filled to within about two inches or so of the top. The corks are then to be driven home and the bottles laid on their sides, so that the corks may soak in the liquor, and by the swelling thus induced may fit more closely and prevent the escape of any portion of gas. It is probable also, that the placing of the bottles in this position opposes a less resistance to the slight fermentative action which should continue after the beer is confined in bottles, in order to produce the desired briskness and creaminess of bottled malt liquors.

In extensive bottling establishments, however, the plan pursued is almost invariably to flatten the beer while in cask, and as soon as the right condition is attained to to bottle off, cork, and finish at one operation.*

If, on drawing out the vent-peg, the liquor appears still and has a somewhat sweet taste, and only a slight degree of briskness, it may be judged to be in good order for

* *See* at end of work illustrated list of the best and newest froms of bottling machines, as supplied to order by W. R. Loftus.

bottling, and the bottles when filled need not be left uncorked for any length of time.

It is hardly necessary to remark that beer which has become decidedly acid and insipid is unfit for bottling.

As a general rule, beer should never be bottled until the fermentation is very feeble, and this is seldom the case with strong ale or porter under a period of nine or twelve months. Weak beer or table ale admits of being bottled much sooner.

Bottling should be done as much as possible in the spring, so that the approaching summer may promote the the ripening of the liquor, as in winter or cool weather it is difficult to get the beer "up," unless the bottles be laid in a place purposely warmed, or packed in hay for a few days before the beer is wanted for use.

It is usually found that the beer drawn from the top down to the middle, or a little past the middle of the hogshead, is the best for bottling, and ripens more speedily in bottle than the lower portions of the contents, which are rarely fine or bright and often have an unpalatable flavor.

When once a cask is begun to be drawn off for bottling the entire quantity in it should be bottled, as the liquor would otherwise become too flat, and there would be a want of uniformity in the flavor and condition of the beer.

Weak malt liquor ripens more quickly in bottle than strong, and by the large accumulation of gas endangers the bursting of the bottles in a greater degree. The bins of bottled liquor should be frequently inspected, and if any of the bottles are found to have burst, all the rest should be immediately set standing up to prevent further losses.

To judge whether bottled beer is "up" and in good drinking order, hold a bottle to the light, and if bubbles of gas are seen rising to the top, it may be taken as an indication that the contents are fit for consumption.

When the remainder of a cask of beer that has been on draught is being bottled, a small piece of loaf sugar put into each bottle has the effect of hastening the ripening and improving the quality of the drink.

The same plau adopted with table beer for summer use produces a very pleasaut aud refreshing beverage. Three

or four stoned raisins dropped into each bottle are equally efficacious.

Again, if on opening any bottled beer it is not sufficiently brisk or is become flat from long keeping, unsound casks, or other causes, the introduction of a little loaf sugar into each bottle will restore the briskness after the bottles have been well corked and laid on their sides in the bins for some time. Home-brewed ales made in small quantity and in cold weather do not answer well for bottling. The heat is apt to fall in the tun at too early a stage, the yeast subsides, and when the beer is drawn off into bottles hardly any secondary fermentation ensues, very little spirit therefore is formed, and the liquor does not keep; of course all this would be prevented if the heat of the tun were maintained by artificial means (tempering pipes) until a proper attenuation had taken place.

Bottles which have been once used should be well cleansed by shaking them up with a little water and small shot, or preferable, small nails. After the shot or nails are taken out it is important to rinse several times with clear water, and then to turn neck downwards to drain and dry. Wet or even damp bottles cause the liquor put into them to become flat and mouldy. Ordinary bottled ale does not often require tying down with string or wire, but it is unsafe to leave porter or table beer with the corks unsecured.

Pack the bottles on their sides, either in sand or saw-dust; the latter should be quite dry or it will heat and endanger the bursting of the bottles. Any beer that may be required for immediate use will ripen quickly if laid in hay.

The corks in all cases should be solid and close and free from worm-holes. It is no economy to buy inferior corks.

Porter and Stout.—Special directions for bottling.—Porter for bottling should be three or four months old, and stout, six or eight months.

Finings should never be used, as they seriously impair the flavor and quality of these beverages. All that is requisite is that the liquor be kept in a cool place until it becomes bright; the bung should then be removed and left out so long as any perceptible briskness continues.

When properly flattened, bottle and allow to remain uncorked for one or two days. If the liquor be put into champagne bottles, it will be necessary to wire them, as from the form of the necks the corks are liable to get blown out by the force of the confined gas.

In the case of porter or stout required for speedy consumption the bottles must be laid down in dry sawdust in the same manner as wine, the temperature of the cellar being kept at about 60°. The liquor will then be fit for drinking in about a month or six weeks. If not wanted so soon the bottles may be advantageously placed standing up, either on the ground or on a shelf, care being taken that the bottles do not touch one another.

CHAPTER XIII.

THE SACCHAROMETER, AND OTHER INSTRUMENTS USED BY BREWERS.

SACCHAROMETERS, THEIR ACTION AND MODE OF CONSTRUCTION.—A short account of the principle and mode of action of the Saccharometer has been given in Chapter I., page 30; it is now necessary to enter somewhat more into detail on this subject, and on the valuation of brewers' worts generally.

The use of the Saccharometer is to furnish us in a quick and convenient manner with a knowledge of the density or specific gravity of worts. Specific gravity is merely another name for comparative weight or density. Every known substance, fluid, solid, or gaseous, on which experiments have been made, is found to have a weight peculiar to itself when any given portion of it is weighed and the result compared with the weight of an *equal bulk* of some common standard.

For fluids and solids the standard chosen is pure or distilled water at a fixed temperature, usually in this country 60° Fahrenheit. All other liquids are compared with water by measuring a definite quantity of each, ascertaining its weight, and then finding by a simple calculation how much heavier or lighter each such liquid is than an equal bulk of water. The weights so determined enable us to classify substances according to the relation they bear in this respect to water, and thus arrange the bodies in allied groups or *species*. Hence the term *specific* gravity, that is, the gravity according to species.

A more useful and intelligible term would be "relative weight or gravity." But the expression specific gravity is too old and too well established to be readily displaced.

Without entering into an account of the operation for

determining the sp. gr. (short for specific gravity) of solid bodies, we have now to remark that the number which denotes the sp. gr. of any liquid is ascertained by dividing the weight of any stated portion of that liquid —a pint, a quart, a gallon, &c.—by the weight of an equal quantity of water. If, for instance, a measured pint of malt wort or a solution of sugar is found to weigh 21 ounces, and a pint of water 20 ounces, then 21 divided by 20 gives the quotient 1·05, which expresses the so-called "specific gravity" of the wort or sugar-solution. Taking any other two equal bulks of this wort and water—a quart, a gallon, or a barrel of each—we should, of course, obtain the same result. Generally, therefore, the specific gravity of the wort in question may be represented by the number 1·05, that is, where water weighs 1, the wort, bulk for bulk, weighs 1·05. But in the valuation of wort, both for commercial and revenue purposes, it is convenient to denote water, the standard fluid, by the number 1000 rather than by unity; the expressions for the specific gravities of worts are accordingly raised in proportion, so that in the case supposed above the specific gravity of the wort would be written 1050 (1000 times 1·05), and similarly in all other instances.

Water then being assumed equal to 1000,* a "degree of gravity" is declared by law to be the one-thousandth part of such assumed value. Now, the one-thousandth part of 1000 is evidently 1, the two-thousandth part is 2, and so on. Thus a "degree of gravity" differs from a degree of *specific* gravity. The former is a definite part of the assumed specific gravity of water; the latter is a unit of specific gravity in general, whether of water or other liquids. It is very important to bear this distinction in mind when dealing with the valuation of worts, especially for revenue purposes. Whenever *specific* gravity is mentioned the number which expresses it should have 1000 (the value of water) included in it—thus, sp. gr. 1010, 1040, 1060, 1125, &c. If from these expressions we respectively deduct 1000, we

* Water might be denoted by any number whatever as well as 1 or 1000, but one of these numbers is the most convenient for calculation.

obtain the corresponding "degrees of gravity," viz., 10, 40, 60, 125, &c.

So long as we have not to compare the values of different worts together, multiplying or dividing these by each other, no confusion or error will arise from using an expression of sp. gr. for one of degrees of gravity, or the reverse. But when worts have to be mixed and their average value determined, or when the comparative produce of different worts has to be found by calculation, then very serious errors would be committed if we were to employ numbers indicating sp. gr. instead of those representing degrees of gravity. For example, suppose we wish to know exactly how much wort at the *gravity* of 57° (or at the *sp. gr.* 1057) is equivalent to 100 barrels of wort at the gravity of 60° (or the sp. gr. 1060).

If we made the calculation thus—

	Sp. gr.		Sp. gr.		Barrels.		Barrels.
As	1057	:	1060	: :	100	:	100·3

we should obtain a result greatly short of the truth. The right way of proceeding is to state the proportion in degrees of gravity—

As 57° : 60° : : 100 : 105·3

Indeed it must be clear, on the smallest reflection, that as 1057 and 1060 both contain the fixed number 1000 (the value of water), the same quotient cannot be obtained as when the remainders, after subtracting 1000 from each, are used as the first two terms of the proportion. Besides, a reference to the table on page 161 will show that at the gravity 57° a barrel of wort contains about 55 lbs. of solid extract, and at 60°, 58 lbs. The 105·3 barrels, multiplied by 55, gives almost exactly the same number of pounds as 100 barrels multiplied by 58. The correctness of the method of using degrees of gravity, and not expressions of specific gravity, in comparing the values of worts, is thus established.

It being understood, therefore, what is meant by degrees of gravity and specific gravity respectively, we have now to explain that the Saccharometer adopted by the Revenue in charging the duty on beer at breweries, and in testing

the value of distillers' worts, indicates degrees of gravity directly when floating in a sample of wort.

The stronger or denser any wort is the higher will the instrument float in it, that is, with less of the stem immersed. It is in this way that the Saccharometer, whatever its construction, serves to indicate the gravity of wort.

Saccharometers are made of metal and of glass; those of metal are more durable, those of glass cheaper at first cost. The metal instruments, after being bruised or otherwise injured, can be restored, at a small expense, to their original form; they can also, when rendered light (inaccurate) by use, be adjusted so as to indicate as correctly as at first. Glass Saccharometers have the advantage of never wearing light, but they are necessarily very delicate and fragile, and require always the most careful handling; once broken, they cannot be repaired.

A form of metal Saccharometer, well adapted for the use of brewers in managing their business under the new revenue regulations, is that manufactured by the publisher of this work. The following description and engraving will convey a clear idea of its construction and mode of action.

Loftus's New Improved Brewing Saccharometer.

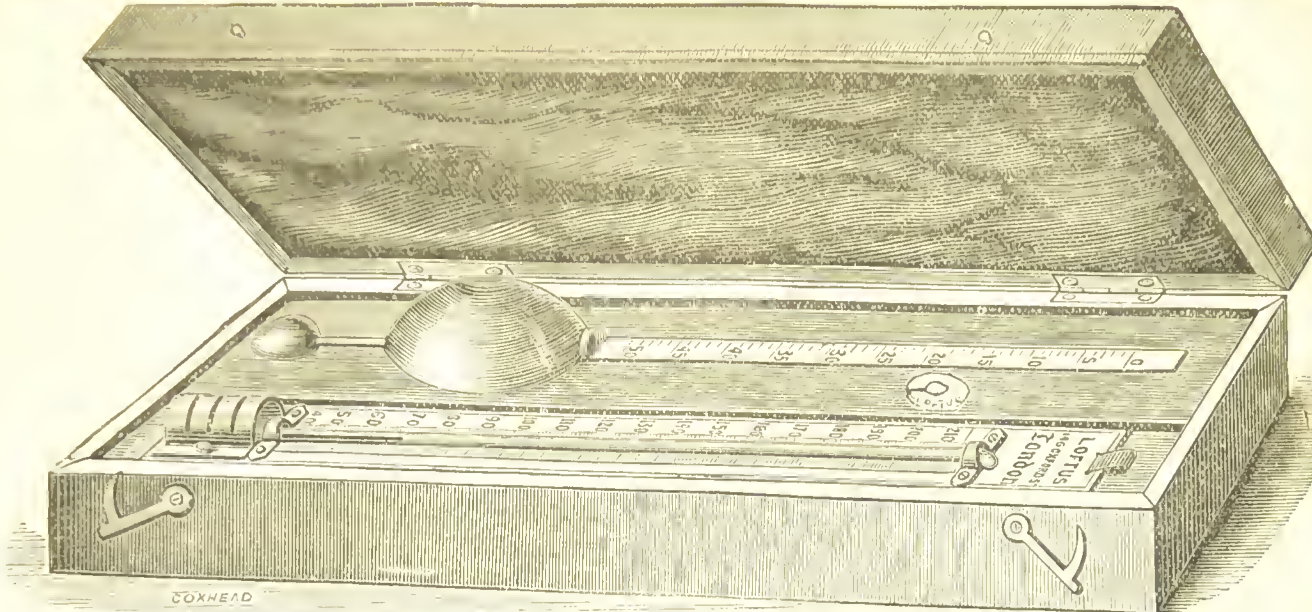
This simple and durable instrument *indicates degrees of gravity* with all the exactness of the Saccharometer used for revenue purposes, and possesses the great practical advantage of requiring only a single weight, or poise, throughout the range of its indications.

It is made either of hard German silver or brass. The German silver instrument is proof against corrosion from the acidity or impurities of the wort, and consequently remains for an indefinitely long time in a state of true adjustment.

The engraving on the opposite page shows this instrument as it lies in its box, with a brewing thermometer by its side. The Saccharometer now described, without attaching the weight, serves to indicate the degrees of gravity—as established by Act of Parliament—of any

NEW IMPROVED BREWING SACCHAROMETER.

For showing the specific gravity of worts, in accordance with the New Beer Duty Act. The most simple and durable Instrument made.



		£	s.	d.
PRICES.—Solid German silver, free from all liability to corrosion, with thermometer and tables, complete	..	3	3	0
Brass ditto ditto ditto	..	2	10	0

wort in which it is placed from 0 to 50°. For worts which exceed this gravity, the weight, or poise (as shown in the engraving by the side of the Saccharometer), must be added, and the second face of the stem (not exhibited in the drawing), which carries the graduation from 50° to 100°, referred to when reading off the indication of the instrument.

The larger egg-shaped hollow ball, or spindle, acts as a float. In opposite ends of this ball are inserted two stems, the upper flat and rectangular in shape, and bearing the two scales of divisions just explained; the lower bulb is appended to the instrument with the object of keeping it in an upright position when floating, and supporting the poise when added. The space on the graduated stem between any two of the numbered points, is divided by short lines into five parts, each of which denotes one degree of gravity. For instance, from 0 to 10, as numbered on the stem, the gravities advance in the order—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and so on.

The thermometer figured in the drawing (and which is furnished at one cost with the Saccharometer) is necessary for observing the temperature of the wort when its gravity is tested. The heat of a sample must never be greater than 220°, the highest range of this instrument. Indeed, it is advisable, for the sake of accuracy, that the liquor, before immersing the Saccharometer, be suffered to cool down to 100°, or below that point, if convenient. The nearer the temperature is to 60° the less will the corrected indication of the gravity of any wort submitted to trial differ from the truth.

Now, in order that the brewer may know how much allowance should be made for the influence of every difference of temperature above or below the standard point 60° in lessening or increasing the density of his worts, it is indispensable that he should provide himself with a trustworthy table of corrections for reducing the apparent or observed gravity, as indicated by the Saccharometer, to the true gravity at 60°. A table of this kind, constructed on the most accurate experimental data, and agreeing at all points with the table used for the same purpose by the revenue officers, but having a more extended range, is supplied by

the publisher, without extra charge, to every purchaser of one of his Saccharometers. The proper method of using it is explained in the front of the table, and is so simple as to require no special elucidation here.

It is, of course, obvious that when a sample of wort is warmer at the time of trial than the standard degree at which the Saccharometer is adjusted, the gravity must be lower than it would be if the temperature of the wort stood at 60°, as the well-known effect of heat is to increase the lightness, and thereby diminish the density of liquids. On the other hand, when the wort is colder than 60° at the time of testing it, its apparent gravity is greater than what it would be at 60° temperature. Accordingly, a correction must be applied in either case to the observed gravity by adding or subtracting some number so as to bring the gravity shown on the Saccharometer to what it would be if the temperature were the same as the standard.

It will be seen from the table of corrections how great an effect is produced on the gravity by any considerable variation of temperature, and how important it is, therefore, never to neglect applying the proper tabular correction.

It is not possible to make the right allowance for differences of temperature in worts by any fixed rule or proportional scale, as the amount of expansion or contraction does not follow a regular gradation. The only system that can be relied on is the use of a table such as has just been described, in which the results of careful experimental observations on worts at the different degrees of temperature are laid down for the guidance of the operator.

Not only does the same wort show a lower or a higher gravity than that given at the standard temperature according as the heat of the sample is greater or less than 60°, but worts of different densities or strengths vary in the amount of their expansion or contraction from the same cause.

A wort of 50° gravity, for example, will not be affected equally with a wort of 70° gravity by the same increase or decrease of temperature; one will not dilate or contract

in bulk so much as the other under a similar rise or fall of temperature. Hence the necessity for having a table of corrections adapted to worts of every degree of gravity, and hence, also, the uselessness and misleading character of the rule of proportional allowances which so many brewers employ.

Instructions for Using the Saccharometer.

Having taken a fair average sample of the wort to be tested, first immerse the thermometer and gently stir the liquid with it, observing that the temperature does not exceed 150°. Then dip the Saccharometer into the wort, as far only as the *bottom* of the upper stem, and lifting it up, return it gradually into the sample; press it about a division lower than the point at which the instrument seems disposed to become stationary, taking care to avoid disturbing it on the removal of the hand.

When at rest, note the division on the stem nearest to the surface of the liquor, and at the same time raising the thermometer partly out of the wort, observe the degree of temperature. If this be higher or lower than 60°, apply the correction shown in the table; the true gravity of the wort at the standard temperature will thus be obtained. The mode of proceeding in all cases is too simple to require any further illustrations or examples than those given in the table supplied with the Saccharometer.

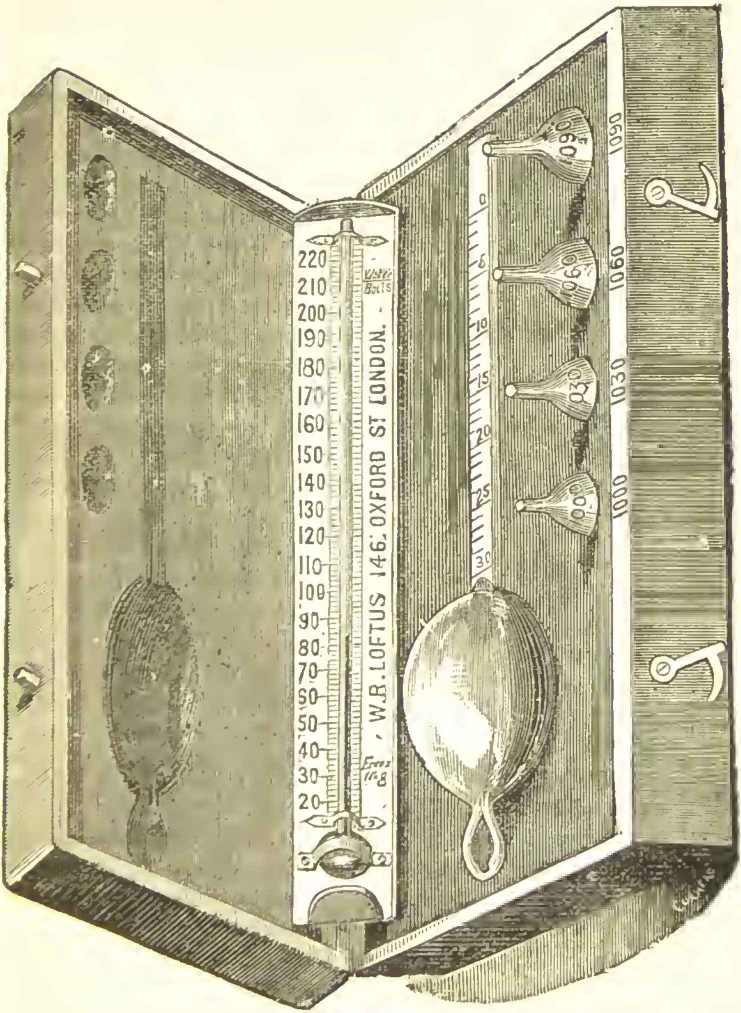
The Revenue Saccharometer.

This instrument, otherwise called "Bate's Saccharometer," after the name of the inventor, is made of brass, and finely gilt, the ball or float being of an elliptical (egg-like) shape, as in the case of the brewing Saccharometer just described, to facilitate its movement in liquids. In the opposite ends of the float are fixed respectively a long flat stem and a loop; the stem bears a scale of divisions numbered downwards from the first, or 0, to 30, each division indicating correctly a "degree

THE REVENUE SACCHAROMETER.

As adopted by H.M. Board of Inland Revenue, and supplied to Revenue Officers for testing the Gravity of Beer.

MANUFACTURED BY W. R. LOFTUS.



PRICE.

	£	s.	d.
Extra best and double gilt, with thermometer and book of tables, complete	4	4	0

of gravity,"* that is, the one-thousandth part of the assumed numerical value of water—1000. There are four poises or weights of different sizes, marked 1000, 1030, &c., each comprising exactly such an augmentation of bulk beyond the first or smallest as the increase of its number represents,—the poise 1030 containing the bulk of 30 divisions of the scale of the stem more than the poise 1000, the poise 1060 an equal excess over poise 1030, and so on; the poises are attached separately to the Saccharometer by their pins, which fit into a conical hole in the bottom of the loop. Whatever poise the density of the wort renders it necessary to use with the instrument, the number marked on it, together with the division of the scale which cuts the surface of the liquor under trial, indicates directly the specific gravity, or rather the *degrees of gravity*, of the wort. Thus, if the instrument, having the poise 1000 attached, sinks in a sample of wort to the division 20 on the stem, the gravity of that wort is at once known to be 20°, subject, of course, to the necessary correction for temperature, as in the case of all other forms of the Saccharometer. This correction is to be obtained from the table already described, or from a set of tables especially constructed to accompany Bate's Saccharometer. It is to be observed, however, that the tables in question are intended chiefly, if not wholly, for use at distilleries, and may be dispensed with as of little utility in their business by brewers.

The engraving on the preceding page gives a good idea of the form and mode of graduation of the Revenue Saccharometer. It is of more delicate make and more expensive, both to purchase and to have re-adjusted, than the equally serviceable instrument first described. Many brewers, however, may prefer to have a Saccharometer of precisely the same kind and construction as that used by the Revenue officers, and all such persons can be supplied to order on advantageous terms by W. R. Loftus, with

* A *degree* of gravity on the Revenue Saccharometer or on Loftus's new improved Brewing Saccharometer is to be carefully distinguished from a pound of gravity as indicated by other forms of the Saccharometer. The latter is 2·6 times the value of the former.

instruments differing in no respect from those employed by the Excise in charging the beer duty.

Glass Saccharometers.

These instruments, as already remarked, are, when well made and adjusted, quite as accurate and serviceable as the metal Saccharometers. They move with great facility in liquids, and so long as they remain unbroken are free from all tendency to become light by wear or corrosion. Great caution must, however, be used in handling them, as a very slight blow or fall will cause a fracture and thus render the instrument wholly useless. The safest plan with a glass Saccharometer is not to wipe or dry it after use, but to transfer it directly to a sample can containing water or wort and leave it there in a secure place until it is again wanted. In the rough work of a brewery, where it is often necessary to carry the Saccharometer from place to place, and test worts on the top of a cask or on the first convenience that comes to hand, glass instruments run much risk of being broken, so that on the whole, metal is found to be the best material, although dearer at first cost.

Engravings of glass Saccharometers, with their accompanying thermometers, &c., are given in the price list at the end of this work, so that it is not requisite to furnish any drawing or description in the present place.

Before putting up a Saccharometer, whether of metal or glass, but especially the former, in its case, the instrument should first be dipped into clean water, if any be at hand, and then gently and carefully wiped dry with a fine cloth.

Attention to this point is particularly needful if the Saccharometer be made of brass and ungilt, as corrosion and consequent lightness are much more readily produced in this class of instruments than where the protection of a coating of fine gold is afforded against the effects of wear or carelessness in the handling. A bulge or bruise, although apparently slight or unimportant, materially

impairs the accuracy of the instrument, rendering its indications untrustworthy, until it has been repaired and readjusted by the manufacturer.

The Saccharometers made by W. R. Loftus of hard German silver (see page 142), resist wear even better than gilt brass instruments, and are also less affected by occasional omissions to wipe and dry them after using.

Thermometers.

The thermometers, or "heat measurers," used in brewing are the same in principle and general details of construction as thermometers made for other purposes. All that seems requisite as respects the brewing thermometer is, that it should be larger than ordinary instruments of the same kind, so as to present an extensive surface of mercury to the liquids in which it is placed, and thus indicate the true heat with promptness, and so that the intervals of the graduation of the scale attached to the tube may be of considerable width, and the marking of the lines and figures bold and distinct. It is also essential that the outer casing should be of strong metal—preferably copper—to enable the instrument to withstand rough usage and transmit the heat instantaneously to the bulb of quicksilver within.

In the best modern thermometers, the back of the glass tube is coated with white enamel; by this device the exact height of the column of mercury is at once perceived even in a bad light, and the reading off greatly assisted when steam or froth happens to envelop the instrument.

Thermometers for testing the heat of mashing liquors, of the goods at any stage of the mashing, and of hot worts generally, are constructed specially for this purpose, the graduation being carried up beyond the boiling point of water or the strongest worts. Such instruments require to be of great sensibility, and to be stoutly encased round the back and sides with a rapidly conducting metal, like copper. It is usual to form the bottom of the metal case into a cup which takes up a

portion of the hot liquor and brings it into immediate contact with the bulb containing the quicksilver. The principal difficulty in applying the thermometer in brewing is that of raising the instrument out of the liquor or goods, and reading off the true indication so quickly as to anticipate any sensible change in the height of the mercury caused by the transition into a cooler medium and the delay that frequently takes place in clearing the tube of condensed vapour or adhering froth or grains. Several ingenious artifices for obviating or diminishing these difficulties have been devised, but the attendant trouble has hitherto limited their application, the ordinary plain thermometer with all its disadvantages being preferred by most practical men.

Blind Scale Thermometers.—The regulating of the heat of the first mash liquor is the nicest part of the brewer's operations, a slight error or inexactness in the subsequent heats being of much less importance. As brewers are sometimes unwilling that strangers, or even their own workmen, should observe the particular temperature at which they commence to mash, or to pitch their gyle-tuns, what are called "blind scale thermometers" are used to prevent the secrets from being divulged. The principle of these instruments is simply the leaving of the space at the back of the mercurial tube blank, and substituting a movable scale which may be applied at any time to the side of the tube, and held in its position with the hand, for the ordinary fixed scale graduated on the surface behind the column of mercury. The brewer having decided at what particular heat he will mash or pitch his tuns, applies the movable scale (which he retains carefully in his own custody) to the side of the instrument, and fastens a sliding index opposite to the exact point indicated on the scale. The instrument thus adjusted is placed in the hands of the workman who is kept in ignorance of the temperature really denoted by the position of the index, and has merely to see that the heat of the liquor is such as to bring the mercury to that precise level in the tube.

Contrivances of this kind are, however, but seldom resorted to in the present day, as the general spread of a

scientific knowledge of the principles of brewing has done away with the secrets formerly so jealously guarded by brewers.

The thermometers employed for noting the heat of the worts during fermentation are usually smaller, have a more limited range, and are less strongly made and encased than the mashing instruments.*

Sample Coolers.—These are simply metal cans or cases provided with tight-fitting lids and a long handle, the object of which is to hold a sample of the hot worts while it is cooled by being plunged into a reservoir of cold water. The accuracy of every observation of the gravity of worts is promoted by reducing the heat to as near 60° as possible. But the delay of cooling the sample to any point lower than such as may be obtained by simply placing the vessel upright in a shallow trough of cold water as soon as the sample is drawn, would interfere too much with the necessary despatch of brewers' operations, and hence the "sample coolers" above described are now hardly ever used.

Various other minor instruments generally required by brewers, such as bottling and corking machines, dipping rods, &c., will be found sufficiently described in the illustrated price lists at the end of this work.

Wort-gravity and Extract.

It has now to be remarked that for all practical purposes the brewer obtains sufficient guidance in any stage of his operations when he informs himself, by means of the Saccharometer, how much heavier the wort he assays is than a like bulk of water, whether he applies the instrument to the infusion of malt or solution of sugar before fermentation, during the action of the yeast, or after the liquor has finished cleansing and assumed the character of finished beer. Nothing more than this is actually needed to enable any person to conduct a brewing process with perfect success—so far at least as

* See Advertisements at end of volume for an illustrated price list of various thermometers used in brewing.

concerns a knowledge of the original saccharine value of the wort and the subsequent changes of density brought about by attenuation. But it is occasionally useful to have a ready means of determining also the proportion of solid matter dissolved in a given measure—as one barrel —of the fresh wort. The quality of malt is very generally expressed by stating that it has been found, when fully mashed, to yield so many pounds of solid "extract" per quarter, the standard quantity of wort in an estimate of this kind being always understood to be four barrels. The amount of extract thus referred to, or the "lbs. *weight* per barrel," as it is called (erroneously) in the language of brewers, stands in immediate relation to the *gravity* as indicated directly by the Saccharometer, although the instrument itself supplies no information respecting the wort, except that of its being so much heavier or lighter, bulk for bulk, than water. It has, for instance, been ascertained by experiment that a wort of 72° gravity contains 69·1lbs. of solid saccharine matter dissolved in each barrel of it; again, that a wort which marks 83° on the Saccharometer, holds in solution 79·7lbs. per barrel of fermentable substance. This extract, or lbs. weight per barrel, may be deduced from the gravity either by an easy calculation on the data (which correspond very closely with the truth), that *gravity* is to *extract* per barrel, as 100 to 96, or by consulting a table given at the end of this article. The difference between "gravity" and "extract" per barrel arises from the fact that the saccharine matter when dissolved in water occupies *very nearly* as much space as it does when existing in a dry state; in other words, it increases the bulk of the water to which it is added by almost the whole of the bulk of the dry sugar itself—the water does not take up more than a small amount of the sugar without undergoing a corresponding enlargement of its own volume.

Every gallon per measure of the solid matter contained in malt or sugar worts weighs on the average about 16lbs. A barrel of distilled water, at 62° F., weighs 360lbs., or 10lbs. per gallon. Now, if one gallon of the dry extract of wort be added to 35 gallons of water, there

will be practically 36 gallons of solution, weighing 366lbs. —that is, 350lbs. for the water and 16lbs. for the extract. But the Saccharometer only shows the excess of the weight of each gallon of wort above the weight of a gallon of water, and the excess in this case is 0·165lbs., or 5·94lbs. per barrel, whereas it is known that 16lbs. of solid extract are present in a barrel of the wort in question.

It follows from this investigation of the subject, that in the example chosen every degree of gravity represents, or is equivalent to, 0·96lbs. of extract per barrel; for if 16·5° gravity correspond to 16lbs. extract, 1° gravity will indicate 0·96lbs. extract; and if any other instance be taken, a like correspondence will exhibit itself. Accordingly, a simple and accurate rule for converting degrees of gravity into pounds of extract per barrel, is to multiply the degrees of gravity, or the indication of the Saccharometer, by the factor 0·96. Thus, for 60° gravity, we have

$$60 \times \cdot 96 = 57\cdot 6 \text{ lbs. extract.}$$

The table above referred to saves the slight trouble of this computation, by showing the equivalent number on inspection.

It is important, therefore, to bear in mind, that the excess in the weight of a barrel—or other stated measure—of any wort, above the weight of an equal quantity of water at the same temperature, does not show the amount of solid matter in solution,—that a wort of 60°, or of the weight of 382 lbs. per barrel gravity, for example, contains much more than 22lbs. of sugar in each barrel.* The reason of this difference will be evident from the explanation above given, and from the consideration that the sugar is more than once and a half as heavy as water, and refuses to

* Richardson, who first drew general attention to the great utility of the Saccharometer, introduced the method of denoting the strength of worts in lbs. of gravity per barrel. He evidently conceived that the difference between the weight of a barrel of any wort and the weight of a barrel of water must be taken to represent the whole of the solid matter present in solution,—that, for instance, a wort of 20 lbs. gravity per barrel contained exactly 20 lbs. weight of extract in every 36 gallons of the liquid—and he accordingly adopted the term "lbs of gravity" as a convenient and accurate indication of saccharine value. But modern brewers, while retaining the name and mode of assaying devised by Richardson, are, no doubt, sensible of the very material disparity between pounds of gravity as shown by the Saccharometer and the weight of solid matter held in solution in the worts. This point has been fully illustrated on page 153.

dissolve without displacing very nearly as much water as is equal to its own bulk. Worts prepared from ordinary cane sugar, and those brewed from malt, contain rather different amounts of extract per barrel. The preceding observations, and the table on page 161, apply to malt worts chiefly, as being more commonly met with in breweries than solutions of sugar.

RULES FOR THE REGULATION OF LENGTHS FROM WORTS.

Assuming that the brewer has proper tables of the capacity of his coppers and fermenting tuns, drawn up in barrels and tenths of a barrel for every inch of their depth, and of his coolers for every tenth of an inch,* we proceed to show how by a very simple calculation the average gravity or strength of the several mashes of a brewing may be obtained, and how the quantity of liquor necessary in certain cases to be boiled away may be determined by reference to the Slide Rule. Worts of different gravities or mashings mix together perfectly in all proportions, and the calculated mean or average gravity coincides very closely in every case with the actual gravity of the mixture as indicated by the Saccharometer.

Having ascertained and noted separately the gravity and gauge of the produce of the different mashes, multiply the number of barrels of each wort by the proper gravity per barrel, and divide the sum of the products so found by

* Actual measurement with water, although involving a good deal of labor, is the most simple method of ascertaining the capacity of vessels of irregular shape like coppers. A hose, with a stop-cock affixed, conveying water to the side of the vessel will, however, greatly facilitate the operation. The total depth should be marked on a rod held in a perpendicular direction within the copper. This distance should then be divided into inches and tenths on the rod, and as each measured quantity of water is poured in the height to which the level rises on the rod should be observed and noted down. It will be an easy matter to construct afterwards a table of barrels per inch from these data. All that is required when the copper is brought into use is to dip the graduated rod to the bottom of the vessel, mark where the surface of the liquor wets the rod, and refer to the table for the corresponding quantity. The same plan may be adopted with respect to the gyle-tuns and other vessels; but it should be recollected that the Excise take their account of the quantity of liquor in a fermenting vessel by the *dry inches*, that is, the depth of the vacant space between the surface of the wort and the top edge of the vessel. This system is adopted because of the difficulty of obtaining a correct *wet* dip of wort in a state of fermentation.

the total number of barrels—the quotient will represent the average or mean gravity of the several worts.

Example.

Suppose the 1st wort of a particular brewing to have measured 13 barrels, and to have indicated a Saccharometer gravity of 94° ; the 2nd wort, 16 barrels and 56° ; and the 3rd wort, 18 barrels and 22°—the calculation of their average strength will be thus performed :—

	Brls.		Gravity.		
1st wort	13	at	94°	....	1222
2nd wort	16	at	56°	....	896
3rd wort	18	at	22°	....	396
Total ..	47				2514

47) 2514 (53·5°

The average gravity of the three worts is therefore 53·5.

If, in this instance, it were desired that the strength of the collected worts should stand at 56° gravity, a certain quantity of water would have to be boiled away to bring the wort to the requisite degree of concentration. The amount necessary to be evaporated is found by the following calculation :—

	Grav.		Grav.		Brls.		Brls.
As	56°	:	53·5°	: :	47	:	44·9

Deducting 44·9 from 47 we have 2·1 barrels, or 76 gallons, as the quantity of water that must be driven off, in addition to the quantity otherwise required, in order to procure a wort of the desired strength. When this is done, instead of 47 barrels of wort averaging 53·5° gravity, the brewer will have 44·9 barrels of 56° gravity. If, on the other hand, the standard strength were fixed at 52°, or at a lower gravity by 1·5° than the average of the worts produced, the quantity otherwise usual to boil away should be reduced by 47 gallons, or about 1·3 barrel ; for as 52° : 53·5 : : 47 : 48·3, and 48·3, less 47, gives 1·3 barrels, or 47 gallons, the amount by which the evaporation otherwise necessary should be lessened, as the wort obtained is stronger than the gravity fixed upon.

Where the same number of barrels of wort is derived from each mashing, then all that is requisite in calculating the average gravity of the several worts, is to divide the sum of the gravities by the number of mashings.

The practice of boiling a wort for a longer time than is otherwise needed, with the object of bringing it to a higher gravity, is in many respects objectionable—as pointed out in Chapter I (page 33)—and is seldom resorted to by brewers of skill and experience. Mashes should be so regulated as to ensure a wort of the quantity and strength intended. Cases, however, will occur, where, owing to some unforeseen circumstance—such as a mistake in the quality of the malt—the brewer is compelled to concentrate his worts by protracted boiling, and here the Saccharometer is his sole reliable guide. To take an instance, let us suppose that in brewing for porter 11 quarters of malt are employed, from which the brewer expects a produce of 64lbs. per quarter; and that 61° gravity is the rate per barrel fixed upon for the strength of the worts. We will suppose the first and second worts already gauged, and their gravities cast, thus:—

1st wort	11	barrels at 78° gravity	858
2nd wort	12·5	„ at 53° „	662·5
Total ..	23·5 weight		1520·5

The third or last mash in the copper, if its quantity and strength were ascertained, and a proper allowance made for heat,* would now amount, we will suppose, to 15 barrels at 17° gravity, or 255lbs. in the whole. This, added to the above totals, would give for the entire extract derived from the goods, 1775lbs., or 38·5 barrels at an average gravity of 46·1°, a result which thus falls considerably short of the estimated produce, as the 11 quarters of malt employed were expected to yield 64lbs. per quarter, or 704lbs. altogether. The wort in the copper must accordingly be reduced in bulk by boiling off a certain number of barrels, and the requisite amount of evaporation may easily be found, by a calculation

* One per cent. should be allowed for increase of bulk for every 5° of heat at which the wort stands above 60°.

similar to the preceding, to be 5·5 barrels. The operation being finished, the result will stand as follows :—

	Brls.		Grav.		
1st wort	11	at	78°	....	858
2nd wort	12·5	at	53°	....	662·5
3rd wort	5·5	at	46°	....	253
	29·0				1773·5

29) 1773·5 (61·1 gravity

The gravity of the 29 barrels of wort produced is thus within one-tenth of a degree of the standard fixed on for the porter—an agreement sufficiently near for every practical purpose.

Rules for Converting Degrees of Gravity into lbs. per Barrel and the Reverse.

Brewers in general have been so long in the habit of reckoning the value of their worts by the system of *lbs. per barrel*, that to many in the trade the method of *degrees of gravity*, now rendered legal in the charge of beer duty at breweries, will at first appear difficult and embarrassing.

A very little study and practice will, however, soon familiarize brewers with the new denomination of values and make them quite expert at converting the one into the other. It will readily be seen that there is nothing essentially different in the two modes : they are both founded on the same fact—density ; either expression is directly derivable from the other by a simple and easy calculation, or by inspection of the table on page 160.

The advantage of denoting the value of worts by degrees of gravity rather than by lbs. of gravity per barrel, is that the former system indicates the relation of weight in a general manner whatever bulks of water and wort or of any two worts may be compared, while the latter confines itself to a particular quantity, arbitrarily chosen.

1st.—Having given the degrees of gravity of any wort as indicated by the revenue Saccharometer, to find the corresponding number of lbs. per barrel.

EXAMPLE.—Let the degrees of gravity be 50, what are the equivalent lbs. per barrel?

Adding 1000 (the assumed density of water) to 50, we have 1050 for the *specific* gravity of this wort. Now, as specific gravity shows the relation of the weights of equal bulks of water and the liquid, we see that where water weighs 1000 the wort in question weighs 1050, or where water weighs 10 the wort weighs 10·50, that is, a gallon of it weighs 10·50lbs. This, multiplied by 36, gives 378, and 378, less 360 (the weight of a barrel of water), gives 18, which number expresses the excess of the weight of a barrel of the wort over the weight of a barrel of water, or in other words, the "lbs. per barrel." The proceeding is the same in all similar cases: and we have accordingly, by simplifying the calculation as far as possible, the following

RULE.—Multipy the degrees of gravity by the decimal ·36; thus—

$$50 \times \cdot 36 = 18$$

2nd.—Having given the lbs. per barrel, to find the degrees of gravity.

EXAMPLE.—As before; let the lbs. per barrel be 18.

360, added to 18, gives 378, the weight of a barrel of the wort: and 378 divided by 360 gives the *specific* gravity of the wort, from which deduct 1000 and the result is the degrees of gravity. This calculation may be reduced to the process expressed by the following

RULE.—Divide the lbs. per barrel by the decimal ·36; thus—

$$\cdot 36 \;)\; 18 \;(50$$

The process in either case is so simple and easily recollected that many will prefer to use it rather than refer to a table.

An easier form of the rule last given, though not yielding quite exact results, is to multiply the lbs. per barrel by 2·8.

$$\text{Thus: } 18 \times 2{\cdot}8 = 50{\cdot}4.$$

TABLE I.

For converting degrees of gravity into lbs. of gravity per barrel.

Degrees of gravity.	lbs. per barrel.	Degrees of gravity.	lbs. per barrel.	Degrees of gravity.	lbs. per barrel.	Degrees of gravity.	lbs. per barrel.	Degrees of gravity.	lbs. per barrel.	Degrees of gravity.	lbs. per barrel.
0	0	26	9·4	51	18·4	76	27·4	101	36·4	126	45·4
1	0·4	27	9·7	52	18·7	77	27·7	102	36·7	127	45·7
2	0·7	28	10·1	53	19·1	78	28·1	103	37·1	128	46·1
3	1·1	29	10·4	54	19·4	79	28·4	104	37·4	129	46·4
4	1·4	30	10·8	55	19·8	80	28·8	105	37·8	130	46·8
5	1·8	31	11·2	56	20·2	81	29·2	106	38·2	131	47·2
6	2·2	32	11·5	57	20·5	82	29·5	107	38·5	132	47·5
7	2·5	33	11·9	58	20·9	83	29·9	108	38·9	133	47·9
8	2·9	34	12·2	59	21·2	84	30·2	109	39·2	134	48·2
9	3·2	35	12·6	60	21·6	85	30·6	110	39·6	135	48·6
10	3·6	36	13·0	61	22·0	86	31·0	111	40·0	136	49·0
11	4·0	37	13·3	62	22·3	87	31·3	112	40·3	137	49·3
12	4·3	38	13·7	63	22·7	88	31·7	113	40·7	138	49·7
13	4·7	39	14·0	64	23·0	89	32·0	114	41·0	139	50·0
14	5·0	40	14·4	65	23·4	90	32·4	115	41·4	140	50·4
15	5·4	41	14·8	66	23·8	91	32·8	116	41·8	141	50·8
16	5·8	42	15·1	67	24·1	92	33·1	117	42·1	142	51·1
17	6·1	43	15·5	68	24·5	93	33·5	118	42·5	143	51·5
18	6·5	44	15·8	69	24·8	94	33·8	119	42·8	144	51·8
19	6·8	45	16·2	70	25·2	95	34·2	120	43·2	145	52·2
20	7·2	46	16·6	71	25·6	96	34·6	121	43·6	146	52·6
21	7·6	47	16·9	72	25·9	97	34·9	122	43·9	147	52·9
22	7·9	48	17·3	73	26·3	98	35·3	123	44·3	148	53·3
23	8·3	49	17·6	74	26·6	99	35·6	124	44·6	149	53·6
24	8·6	50	18·0	75	27·0	100	36·0	125	45·0	150	54·0
25	9·0										

TABLE II.

Showing the lbs. weight of solid extract or fermentable matter per Barrel, corresponding to degrees of gravity.

Degrees of gravity.	lbs. of extract per barrel.	Degrees of gravity.	lbs. of extract per barrel.	Degrees of gravity.	lbs. of extract per barrel.	Degrees of gravity.	lbs. of extract per barrel.	Degrees of gravity.	lbs. of extract per barrel.
0	0	27	25·9	53	50·9	79	75·8	105	100·8
1	1·0	28	26·9	54	51·8	80	76·8	106	101·8
2	1·9	29	27·8	55	52·8	81	77·8	107	102·7
3	2·9	30	28·8	56	53·8	82	78·7	108	103·7
4	3·8	31	29·8	57	54·7	83	79·7	109	104·6
5	4·8	32	30·7	58	55·7	84	80·6	110	105·6
6	5·8	33	31·7	59	56·6	85	81·6	111	106·6
7	6·7	34	32·6	60	57·6	86	82·6	112	107·5
8	7·7	35	33·6	61	58·6	87	83·5	113	108·5
9	8·6	36	34·6	62	59·5	88	84·5	114	109·4
10	9·6	37	35·5	63	60·5	89	85·4	115	110·4
11	10·6	38	36·5	64	61·4	90	86·4	116	111·4
12	11·5	39	37·4	65	62·4	91	87·4	117	112·3
13	12·4	40	38·4	66	63·4	92	88·3	118	113·3
14	13·4	41	39·4	67	64·3	93	89·3	119	114·2
15	14·4	42	40·3	68	65·3	94	90·2	120	115·2
16	15·4	43	41·3	69	66·2	95	91·2	121	116·2
17	16·3	44	42·2	70	67·2	96	92·2	122	117·1
18	17·3	45	43·2	71	68·2	97	93·1	123	118·1
19	18·2	46	44·2	72	69·1	98	94·1	124	119·0
20	19·2	47	45·1	73	70·1	99	95·0	125	120·0
21	20·2	48	46·1	74	71·0	100	96·0	126	121·0
22	21·1	49	47·0	75	72·0	101	97 0	127	121·9
23	22·1	50	48·0	76	73·0	102	97·9	128	122·9
24	23·0	51	49·0	77	73·9	103	98·9	129	123·8
25	24·0	52	49·9	78	74·9	104	99·8	130	124·8
26	25·0								

The principle on which this table is formed is, that every 0·96 lb. solid extract in one barrel of wort gives one degree of gravity. The slight concentration that takes place in solution is neglected as of no practical importance. The table may be used without much error for both malt and sugar worts.

CHAPTER XIV.

Record of Observations. Brewhouse Journal.

Every brewer, on however small a scale, should make a concise, regular, entry of the quantities of materials used in each brewing, with a memorandum of the date, the heat of the weather, the description of liquor brewed, and any other necessary or desirable particulars.

It is usual to enter the observations roughly on a slate at first, and to transfer the memoranda afterwards into a properly-titled book or journal.

The following is a specimen of the journal commonly used.

Another and more comprehensive form is supplied by W. R. Loftus, the publisher of this work, in books, of convenient sizes.

* See pages 164, 165.

WATER IN BREWING.

THE *importance* of the *quality* or character of the *water used* in brewing is now generally recognised, the old idea that *soft water* is the best being justly exploded. It has come to be known, by long experience and observation, that not only is a better and brighter extract obtained from malt when *water of a certain hardness is employed*, but also that, by attending to this condition, the beer *fines* more readily and surely, without the loss of body which the action of fining entails. Brewers on a large scale, especially those who make the finer classes of pale ales, are so sensible of the necessity of having the right proportion of mineral matter in their mashing liquor, that they *regularly test* the supplies of the water companies, or the product of their own wells, before filling their coppers or wetting their goods. It may, indeed, be said, with truth, that the state of the water about to be used demands quite as careful examination as the quality of the malt and hops. But it is scarcely in the power of every brewer to satisfy himself by the *proper tests* as to the fitness of the water on his premises to make good beer. Although the mode of analysis is simple enough in competent hands, and the requisite apparatus is neither costly nor elaborate, still the process *has* to be learnt and frequently practised, at the expense of no little time and patience, before the operator can be certain that his results will not mislead him, and endanger the success of his brewings. No guide at all is to be preferred to a fallacious guide on a nice and critical point like this.

It must be quite clear, therefore, that in ordinary cases, where the necessary skill and means for estimating the *hardness* or *purity* of the *water* are absent, the most prudent course for a brewer is to entrust samples to a professional person who undertakes examinations of the kind, and can be held responsible for the correctness of the reports he furnishes. There is only one circumstance that has hitherto kept the trade from availing themselves more largely of the services of such persons; that circumstance is undoubtedly the *exorbitant charges* made in most instances for the work done, and the *theoretical*, if not *unintelligible*, *terms* in which the answer is too frequently conveyed. What can be more unsatisfactory and discouraging to a merely practical brewer, who carries on a small business, and sends up a sample of water which he fears is the cause of the *muddiness* and *rapid souring* of his ales, than to be told, after paying *five guineas*, and perhaps waiting a month for the information, that the sample is found to contain *so many grains or grammes of carbonate of lime, potash, or soda in the thousand parts*, without a hint as to where the *defect* lies, or how a *remedy* may be applied? How much wiser is he than before for this intelligence?

By resorting to the BREWERS' LABORATORY, 146, OXFORD STREET, a much more simple and useful report may be ensured at a fourth of the outlay, and within a few days after the sample is received.

Since opening our Laboratory we have examined some hundreds of samples from all parts of the three kingdoms, and the letters we have received from brewers testify to the general satisfaction we have given. Our analysis is thoroughly practical, and every report sent from our Laboratory is written in language easily understood by the brewer. We note the good and bad qualities of each sample—its fitness or unfitness for brewing—and, where a water is defective, suggest a remedy.

It is important to observe that at least a gallon of the water to be tested must always be forwarded, and that for the sake of security a strong jar with sealed cork should be used.

TERMS—30s. each Sample. Three or more Samples, 25s. each.

Reports furnished without delay. All the really essential qualities of the water carefully noted for the guidance of the brewer.

Date.	Quarters of Malt.	Lbs. of Hops.	Temp. of Air.	Barrels of Liquor.	Temp. of Liquor.	Hours on Mash.	Barrels of Wort.	Density of Wort.	Temp. of Wort.	Extract.	Time boiled.	Length.	Final Density.	Extract per Quarter.	Lbs. of Yeast.	Attenuation. 1st Day.	Attenuation. 2nd Day.	Attenuation. 3rd Day.	Attenuation. 4th Day.	Temp. of Tun.	Temp. of Air.	Barrels of Ale.	Barrels of Table.	Observations.
Brought forward	60	360	...	...	...	...	...	...	...		...	...	...	...	...	...	...	...	...	...	...	168	34	
February 1st......	10	60	42	18 16 10	188 188 186	2 1¼ 1½	12½ 14¾ 9¼	88° 58° 26°	142 146 148	395· 306·8 85·1	¾ 1 1													Racked with 9 gallons old ale per barrel.
				44		4¾	36½	60°		786·9	2¾	30	68°	lbs.										
Table	...	......	...	8	193	½	9½	14°		49·4		6	22°	252										Feb. 15. With the aid of finings, beer became perfectly bright ten days after racked.
e. 9	...	......	...	...	......	...	......	......	......	....	...	...	......	......	15	......	......	......	......	62	41	Roused		
February 2, m. 6	...	......	...	...	......	...	......	......	......	....	...	...	......	......	10	67°	......	......	......	64	42	ditto		
e. 8	...	......	...	...	......	...	......	......	......	....	...	...	......	......	...	64°	......	......	......	65	45	ditto		
" 3, m. 7	...	......	...	...	......	...	......	......	......	....	...	...	......	......	10	......	53°	......	......	66	46	ditto		Much admired.
e. 6	...	......	...	...	......	...	......	......	......	....	...	...	......	......	...	......	47°	......	......	66	44	ditto		
" 4, m. 6	...	......	...	...	......	...	......	......	......	....	...	...	......	......	10	......	......	40°	......	68	48	ditto		
e. 5	...	......	...	...	......	...	......	......	......	....	...	...	......	......	...	......	......	34°	......	68	48	ditto		
" 5, m. 7	...	......	...	...	......	...	......	......	......	....	...	...	......	......	...	......	......	......	33°	68	44	ditto		
noon	...	......	...	...	......	...	......	......	......	....	...	...	......	......	...	......	......	......	31°	70	48			
e. 4	...	......	...	...	......	...	......	......	......	....	...	...	......	......	...	......	......	......	29°	70	48	29½	6	
Carried forward	70	420																				197½	40	

SPECIMEN OF LOFTUS'S BREWHOUSE JOURNAL.

Gyle No. ________ *Quality.*

DATE OF BREWING	MALT.			HOPS.		No. of Mashes.	No. of Barrels of Liquor.	Heat of Liquor.	Time of Mashing.	Time of Standing on Goods.	Tap Heat.	Quantity of Wort.	Gravity.	No. of Barrels of Wort in the Copper.	Gravity in Copper.	Time of Boiling.
	Quantity	Quality	Roasted	Quantity	Quality											
								Degrees	H. M.	H. M.	Degrees.					H. M.

Temperature of the Atmosphere ________ *Degrees.*

Barrels of Wort Turned out.	Pitching Gravity.	Heat.	Length in the Square.	Lbs. of Yeast.	No. of the Square.	Total Saccharine per Gyle.	Average Gravity.	Gravity per Quarter of Malt.	HEAT AND GRAVITY.						Heat and Gravity at Cleansing.	Final Attenuation.	Barrels Stored.
									Day	Day	Day	Day	Day	Day			
									Heat	Heat	Heat	Heat	Heat	Heat	Heat		
									Grav	Grav	Grav	Grav	Grav	Grav	Grav		

REMARKS.

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